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ACADEMY OF SCIENCES USSR

COMMITTEE ON GEODESY AND GEOPHYSICS

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REPORT ON SCIENTIFIC WORKS ON THE SEISMOLOGY AND PHYSICS OF THE EARTH'S CORE

Presented At The International Association of Seismology And Physics Of the Earth's Core To The XI General Assembly Of The International Geodetic And Geophysical Union

Publishing House Of The Academy Of Sciences USSR

Moscow 1957

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I. SEISMOLOGY

1. INFORMATION ON SEISMOLOGICAL ORGANIZATIONS OF THE USSR

RESEARCH ORGANIZATIONS

The central research organization where investigations in seismology are being conducted is the Institute of Physics of the Earth of the Academy of Sciences of the USSR in Moscow. It was established in 1956 during the reorganization of the Geophysical Institute.

The research work in this institute is being conducted along the following main directions.

Study of earthquakes which take place on the territory of the Soviet Union(analysis and generalization of seismic observations; preparation of seismic maps; study of ph ysical and geological causes and conditions of occurrence of earthquakes); study of the physics of seismic waves and the development, on this basis, of new methods of interpretation of seismic data; study of the regularities of seismic effects on structures; development of methods and accomplishment of seismic districting of the territory of the Soviet Union; mini[illegible]rization of seismic processes; creation of new types of seismic apparatus; study of the inner structure of the earth and of the earth's crust on the basis of seismic data.

Research work in seismology is being conducted in the branches of the Academy of Sciences of the USSR which exist in seismically active regions: by the Moldavian(Kishinev), Kola (Murmansk), East-Siberian(Irkutsk), and Sakhalin complex research institute(Sakhalin Island), and also in the academies of sciences of the union republics(Azerbaydzhan, Armenian, Georgian, Kazakh, Kirgiz, Tadzhik, Turkmen, Uzbek, and Ukrainian). Some of these academies have specialized organizations: Institute of Geophysics of the Academy of Sciences of the Georgian SSR(Tbilisi), Institute of Seismology of the Academy of Sciences of the Tadzhik SSR (Stalinabad), Institute of Physics and Geophysics of the Academy of Sciences of the Turkmen SSR(Ashkhabad), Division of Seismology of the Academy of Sciences of the Kirgiz SSR(Frunze), Seismic Department of the L'vov Branch of the Academy of

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Sciences of the Ukrainian SSR(L'vov).

The main directions of the scientific investigations by the branches of the Academy of Sciences of the USSR and the organizations of the academies of sciences of the union republics are the detailed study of the seismism of the corresponding regions, the investigation of the after-effects of earthquakes, the development of other scientific problems in cooperation with the Institute of Physics of the Earth of the Acad. Sci. USSR and other scientific organizations.

Investigations in seismology pertinent to the study of volcanoes and their activity are being conducted in the Laboratory of Volcanology of the Acad. Sci. USSR, which has specialized observation stations in Kamchatka.

The Moscow State University is conducting work on the study of the inner structure of the earth and of the earth's crust and on the development of apparatus for observations of microseismic vibrations.

The Leningrad State University is conducting work on the development of a dynamic theory of elastic waves.

All the work in seismolgy in the Soviet Union is being directed and coordinated by the Council of Seismology of the Academy of Sciences of the USSR. The staff of the council, which is reviewed periodically, includes about 25 scientists of different specializations(seismology, geology, engineers, architects, etc), representatives of scientific and industrial organizations.

Not less than twice a year, the Council on Seismology conducts conferences(sessions) lasting 3-5 days, at which the results of scientific work in seismology are discussed, plans are developed for forthcoming scientific investigations and the development of scientific organizations, and discussions are conducted on scientific problems in the field of seismology.

The conferences(sessions) of the Council on Seismology are attended usually by representatives of all scientific organizations in which work on seismology is being carried on.

As a result of the work of the council, actual directions

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of scientific investigations are established and planning and cooperation in scientific work is carried out.

Between the sessions of the council, the work is conducted by its bureau.

The Council on Seismology establishes a uniform procedure of observations at the seismic stations, issues instructions for the personnel of the stations, and issues four times a year the Byulleten seti seysmicheskikh stantsiy SSR(Bulletin of the Network of Seismic Stations of the USSR) and the scientific journal Byulleten Soveta po seysmologii(Bulletin of the Council on Seismology).

Seismic Stations

The total number of seismic stations in the Soviet Union is 76. The stations belong to different services and organizations Their activity is coordinated by the Council on Seismology of the Acad. Sci. USSR.

The stations are divided into 3 classes: teleseismic, general type, and regional type.

The teleseismic stations are intended for the study of the total seismism and inner structure of the earth and also microseisms of the 1st order. The stations are equipped with seismographs of the B. B. Golitsyn system with galvanometric registration. The constants of th e instruments are $T_1=T_2\approx 12$ sec (for horizontal seismograph s of the Sverdlovsk station, $T_1=T_2\approx 24$ sec). The damping $D_1=D_2=1$. Maximum amplification V_{max} 1000.*

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*Here and henceforth:

$T_1=2\pi/n_1$ and $T_2=2\pi/n_2$ are the periods of the natural oscillation of the pendulum and galvanometer;

$D_1=\varepsilon_1/n_1$ and $D_2=\varepsilon_2/n_2$ are the damping constants of the pendulum and galvanometer;

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ε_1 and ε_2 are the damping coefficients of the pendulumand galvanometer;

V, $\overline{V}$ are the amplification coefficients;

$\sigma^2=\sigma_1\sigma_2$ is the coupling coefficient;

σ_1 and σ_2 are the coefficients which characterize the electrical coupling between the pendulum and the galvanometer in the differential equations of the seismograph with galvanometric registration;

$$\ddot{\theta}+2\varepsilon_1\dot{\theta}+n_1^2\theta=-\frac{\ddot{x}}{l}+2\varepsilon_1\sigma_1\dot{\varphi}$$
$$\ddot{\varphi}+2\varepsilon_2\dot{\varphi}+n_2^2\varphi=2\varepsilon_2\sigma_2\dot{\theta}$$

(θ and φ are the angular deviations of the pendulum and galvanometer loop from the position of equilibrium; x is the displacement of the soil).

The general-type stations are intended for the solution of the same problems as the teleseismic and also for the study of the seismism of the territory of the USSR, for the study of the mechanism and energy of earthquakes and the structure of the earth's core.

The instruments for these stations are seismograph s of the D. P. Kirnos system with galvanometric registration (SGK and SVK) The instrument constants are: $T_1\approx 12.5$ sec; $T_2\approx 1.2$ sec; $D_1\approx 0.45$; $D_2\approx 5.0$; V=1 000-2 000 on periods from 0.25 to 10 sec; $\sigma^2\leq 0.1$ (for SGK); $\sigma^2=0.2$-0.3 (for SVK).

The regional-type stations are intended for the detailed study of the seismism of individual seismically active regions.

The stations are equipped essentially with h ighly sensitive seismograph s of the D. A. Kharin system with galvanometric registration (GSKh and VSKh). The instrument constants are: $T_1=0.6$-1 sec; $T_2=0.2$-0.4 sec; $D_1=0.5$-1; $D_2=1.5$-2; $\sigma^2\approx 0.3$; V_{max}=10 000-50 000 on the periods 0.2-0.5 sec.

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Certain stations of this ty pe are equipped with electrodynamic vibrographs of the D. P. Kirnos system "VEGIK" (T_1=0.6 sec, D_1=0.5, T_2=0.06 sec, D_2=3.0, $\bar{V}$ 18 000, σ^2=0.2).

Various stations are equipped with seismographs of the P. M Nikiforov system with optical registration SN (T_1=2.0 sec, D_1=0.5-0.6, $\bar{V}$=400) and seismographs of the Seismological Institute system SI (T_1=2.0 sec, D_1=0.5-0.6, $\bar{V}$=1 500). To record strong earthquakes, seismographs with mechanical registration of the D. P. Kirnos system SMR-2 (T_1=5.0 sec, D_1=0.45, $\bar{V}$=7) are utilized.

Table

Name of station	Organization to which the station belongs	Geographic coordinates °N	°E	Instruments system (as of 1 Jan 57)
Moscow	Institute of Physics of the Earth, Acad. Sci. USSR	55°44'	37°38'	B. B. Golitsyn an D. P. Kirnos
Abastumani	Institute of Geophysics, Acad. Sci. Georgian SSR	41 45	42 50	D. A. Kharin
Alma-Ata	Institute of Physics of the Earth, Acad. Sci. USSR	43 16	76 57	D. P. Kirnos (galvanometer and mechanical registration)
Alma-Ata 2	Institute of Physics of the Earth, Acad. Sci. USSR	43 16	77 23	D. P. Kirnos
Andizhan	Institute of Physics of the Earth, Acad. Sci. USSR	40 45	72 22	D. P. Kirnos (galvanometer an d mechanical registration)
Alushta	Institute of Physics of the Earth, Acad. Sci. USSR	44 42	34 25	D. A. Kharin
Apatity	Kola Branch, Acad. Sci. USSR	67 35	33 18	D. P. Kirnos
Akhalkalaki	Institute of Geophysics, Acad. Sci. Georgian SSR	41 24	43 29	D. A. Kharin
Ashkhabad	Institute of Physics and Geophysics, Acad. Sci. Turkmen SSR	37 57	58 21	D. P. Kirnos (galvanometer and mechanical registration)

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Bogdanovka	Institute of Geophysics, Acad. Sci. Georgian SSR	41 16	43 36	D. A. Kharin
Bayram-Ali	Institute of Physics of the Earth, Acad. Sci. USSR	36 36	62 07	D. P. Kirnos
Baku	Institute of Physics of the Earth, Acad. Sci. USSR	40 23	49 54	B. B. Golitsyn and D. P. Kirnos
Bakuriani	Institute of Physics of the Earth, Acad. Sci. USSR	41 44	43 31	D. A. Kharin
Borzhomi	Institute of Geophysics, Acad. Sci. Georgian SSR	41 50	43 23	D. P. Kirnos
Vannovskaya	Institute of Physics and Geophysics, Acad. Sci. Turkmen SSR	37 57	58 06	D. P. Kirnos Vibrograph
Vladivostok	Institute of Physics of the Earth, Acad. Sci. USSR	43 07	131 54	D. P. Kirnos
Garm	Institute of Physics of the Earth, Acad. Sci. USSR	39 00	70 18	D. P. Kirnos (galvanometer with mechanical registration)
Gissar	Institute of Physics of the Earth, Acad. Sci. USSR and Institute of Seismology, Acad. Sci. Tadzhik SSR	38 28	68 34	D. A. Kharin D. P. Kirnos Vibrograph
Gori	Institute of Geophysics, Acad. Sci. Georgian SSR	41 59	44 07	D. P. Kirnos D. A. Kharin
Goris	Institute of Physics of the Earth, Acad. Sci. USSR	39 30	46 20	D. P. Kirnos D. A. Kharin
Groznyy	Institute of Physics of the Earth, Acad. Sci. USSR	43 19	45 45	D. P. Kirnos
Dzhergetal	Institute of Physics of the Earth, Acad. Sci. USSR	39 13	71 13	D. P. Kirnos D. P. Kirnos Vibrograph
Dusheti	Institute of Geophysics, Acad. Sci. Georgian SSR	42 05	44 42	Seismological Institute, Acad. Sci. USSR
Yerevan	Institute of Physics of the Earth, Acad. Sci. USSR	40 11	44 30	D. P. Kirnos (galvanometer and mechanical registration)

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Zugdidi	Institute of Geophysics, Acad. Sci. Georgian SSR	42	31	41	53	D. A. Kharin
Ili	Institute of Physics of the Earth, Acad. Sci. USSR	43	57	77	05	D. A. Kharin
Irkutsk	Institute of Physics of the Earth, Acad. Sci. USSR	52	16	104	19	B. B. Golitsyn
Kabansk	Institute of Physics of the Earth, Acad. Sci. USSR	52	03	106	39	D. P. Kirnos
Kara-Su	Institute of Physics of the Earth, Acad. Sci. USSR and Institute of Seismology, Acad. Sci. Tadzhik SSR	38	29	68	59	D. P. Kirnos Vibrograph
Kizil-Arvat	Institute of Physics of the Earth, Acad. Sci. USSR	39	12	56	16	D. P. Kirnos
Kirovabad	Institute of Physics of the Earth, Acad. Sci. USSR	40	44	46	22	D. P. Kirnos
Kishinev	Moldavian Branch, Acad. Sci. USSR	47	01	28	50	D. P. Kirnos
Klyuchi	Laboratory of Volcanology, ACAD. Sci. USSR	56	19	160	52	D. P. Kirnos
Kulyab	Institute of Seismology, Acad. Sci. Tadzhik SSR	37	54	69	45	D. P. Kirnos (galvanometer and mechanical registration)
Kuril'sk	Sakhalin Complex Insitute, Acad. Sci. USSR	45	14	147	52	D. P. Kirnos
Kurmenty	Institute of Physics of the Earth, Acad. Sci. USSR	43	03	78	17	D. A. Kharin
Kyakhta	Institute of Physics of the Earth, Acad. Sci. USSR	50	22	106	27	D. P. Kirnos
Lenina-kan	Acad. Sci. Armenian SSR	40	46	43	51	Seismological Institute Acad. Sci. USSR
Lenkoran	Institute of Physics of the Earth, Acad. Sci. USSR	38	46	48	50	D. P. Kirnos P. M. Nikiforov
L'vov	L'vov Branch, Acad. Sci. Ukrainian SSR	49	49	24	02	D. P. Kirnos
Magadan	Institute of Physics of the Earth, Acad. Sci. USSR	39	33	150	48	D. P. Kirnos

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Makhach-Kala	Institute of Physics of the Earth, Acad. Sci. USSR	42 58	47 30	D. P. Kirnos
Mirnyy	Institute of Physics of the Earth, Acad. Sci. USSR	66 33	93 00	D. P. Kirnos
Murgab	Institute of Physics of the Earth, Acad. Sci. USSR	38 22	73 25	D. P. Kirnos
Namangan	Institute of Physics of the Earth, ACAD. Sci. USSR	40 59	71 40	D. P. Kirnos
Naryn	Institute of Physics of the Earth, Acad. Sci. USSR	41 26	75 59	D. P. Kirnos
Nakhichevan	Institute of Physics of the Earth, Acad. Sci. USSR	39 12	45 24	D. P. Kirnos
Obi-Garm	Acad. Sci. Tadzhik SSR	38 43	69 43	D. P. Kirnos (galvanometer and mechanical registration)
Petropavlovsk-na-Kamchatke	Institute of Physics of the Earth, Acad. Sci. USSR	53 01	158 39	D. P. Kirnos (galvanometer and mechanical registration)
Przheval'sk	Institute of Physics of the Earth, Acad. Sci. USSR	42 29	78 24	D. A. Kharin
Pulkovo	Institute of Physics of the Earth, Acad. Sci. USSR	59 46	30 19	B. B. Golitsyn D. P. Kirnos
Pyatigorsk	Institute of Physics of the Earth, Acad. Sci. USSR	44 02	43 04	D. P. Kirnos
Rybach'ye	Institute of Physics of the Earth, Acad. Sci. USSR	42 28	76 11	D. P. Kirnos
Samarkand	Acad. Sci. Uzbek SSR	39 40	66 59	D. P. Kirnos
Sverdlovsk	Institute of Physics of the Earth, Acad. Sci. USSR	56 50	60 38	B. B. Golitsyn D. A. Kharin
Semipalatinsk	Institute of Physics of the Earth, Acad. Sci. USSR	50 24	80 15	D. P. Kirnos
Simferopol	Institute of Physics of the Earth, Acad. Sci. USSR	44 57	34 07	D. P. Kirnos D. A. Kharin
Sochi	Institute of Physics of the Earth, Acad. Sci. USSR	43 35	39 43	D. P. Kirnos

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Stalinabad	Institute of Seismology, Acad. Sci. Tadzhik SSR	38 34	68 46	D. P. Kirnos (galvanometer and mechanical registration) D. A. Kharin
Stepanavan	Acad. Sci. Armenian SSR	41 00	44 23	D. A. Kharin
Tashkent	Institute of Physics of the Earth, Acad. Sci. USSR	41 20	69 18	B. B. Golitsyn
Tbilisi	Institute of Geophysics, Acad. Sci. Georgian SSR	41 43	44 48	B. B. Golitsyn
Tiksi	Institute of Physics of the Earth, Acad. Sci. USSR	71 38	128 52	D. P. Kirnos
Uglegorsk	Sakhalin Complex Institute, Acad. Sci. USSR	49 05	142 04	D. P. Kirnos
Uzhgorod	L'vov Branch, Acad. Sci. Ukrainian SSR	48 38	22 18	D. A. Kharin
Fabrichnaya	Institute of Physics of the Earth, Acad. Sci. USSR	43 11	76 24	D. A. Kharin
Feodosiya	Institute of Physics of the Earth, Acad. Sci. USSR	45 01	35 23	D. P. Kirnos
Fergana	Institute of Physics of the Earth, Acad. Sci. USSR	40 23	71 47	D. P. Kirnos
Frunze	Institute of Physics of the Earth, Acad. Sci. USSR	42 53	74 36	D. P. Kirnos
Khorog	Institute of Physics of the Earth, Acad. Sci. USSR	37 30	71 34	D. P. Kirnos (galvanometer and mechanical registration)
Khorongon	Institute of Physics of the Earth, Acad. Sci. USSR and Institute of Seismology Acad. Sci. Tadzhik SSR	38 40	68 47	D. P. Kirnos Vibrograph
Chernovitsy	Chernovitsy State University	48 17	25 56	P. M. Nikiforov

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Chernovitsy-2	L'vov Branch, Acad. Sci. USSR	48	18	25	56	D. P. Kirnos
Chilik	Institute of Physics of the Earth, Acad. Sci. USSR	43	34	78	25	D. A. Kharin
Chimkent	Institute of Physics of the Earth, Acad. Sci. USSR	42	19	69	36	D. P. Kirnos
Shemakha	Institute of Physics of the Earth, Acad. Sci. USSR	40	38	48	38	D. P. Kirnos
North-Sakhalinsk	Sakhalin Complex Institute, Acad. Sci. USSR	47	01	142	43	D. P. Kirnos
Yalta	Institute of Physics of the Earth, Acad. Sci. USSR	44	30	34	10	D. P. Kirnos (galvanometer and mechanical registration) D. A. Kharin

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2. INFORMATION ON SEISMOLOGY WORK DURING 1951-1956

Concrete data about the basic results of work in seismology can be derived from the below-appended annotated bibliography which consists of the following divisions:

1. General textbooks.
2. Study of seismism.
3. Processing of seismic observations.
4. Conditions and causes of earthquakes.
5. Seismic districting and seismic stability of structures
6. Structure of the earth on the basis of seismic data.
7. Theoretical and experimental study of seismic waves.
8. Seismic apparatus.
9. Microseisms. Tsunami.
10. Bulletins of the networks of seismic stations.

Below is given general information only about the main results of the work in these divisions.

The divisions dealing with the study of seismism contains investigations of the territorial distribution of earthquakes, the development and creation of methods for the study of seismism on the basis of more accurate and detailed instrument observations, and also on geological(tectonic) data.

During the past years, a study was made of the seismism of pleistocene regions of certain strong earthquakes(districts of Shemakha, Ashkhabad, North Tyan-Shan, Garm, and others). Seismic stations with apparatus of increased sensitivity were established in these districts, which made it possible to determine the positions of the epicenters of weak earthquakes and the depth of their centers. Also, special attention was paid to the study of the characteristics of the structure of the earth's crust by geological methods.

Besides this, a detailed study was made of the after-effect of strong earthquakes during these years and a generalization was made of the observations over many years by the seismic stations of the USSR of the earthquakes of certain zones (Caucasus, Kurile-Kamchatka zone, Central Asia, etc). These generalizations were analyzed with consideration of data of the tectonics. As a result, discovery was made of the relationship

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between earthquakes and structural characteristics in the structure of the earth's crust. A comparison was made between the data on the frequency and energy of earthquakes.

In processing seismic observations, main attention was concentrated on the development of methods for determining the position of the centers of earthquakes from the data of close stations. This is related to the development of the network of seismic stations in the USSR in seismically active zones and with the organization of movable local networks of seismic stations when the the epicentral distances were comparable with the depths of the centers. New means were devised for determining the position of the centers of earthquakes from data of the direction of the course of waves and from the correlations among the records of the vibrations of earthquakes at closely situated seismic stations, similar to the procedure during seismic survey. Considerable attention was directed to the development of instrument intensity of earthquakes (Guthenberg and Richter scale) as applicable to the USSR. A study was made of the possibility of determining the intensity of earthquakes in points for a given depth of center and relative energy. Means were developed for taking into account geological heterogeneities of the earth's crust for a more accurate determination of the position of centers from data of seismic stations.

In studying the conditions and causes of earthquakes, the work was carried on in the direction of the discovery of the prognostic symptoms and the study of the centers of earthquakes and geological criteria of seismism. The basis of the study of the centers was their miniaturization by concentrated sources(multiples of different orders). On the basis of theoretical calculations and from observations of longitudinal and transverse waves, a determination was made of the direction of forces acting in the centers and of the probable directions of dislocations which cause the earthquakes. Data of this type were obtained for earthquakes in the Far East, Central Asia, and the Caucasus. A study was made of the breaks in the continuity of rocks on the basis of their laboratory miniaturization and the study of the formation of ~~fxx~~

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folded and discontinuous dislocations in the earth's crust of seismically active zones of the Soviet Union. Observations were made of weak earth earthquakes in order to study individual fractures of the earth's core, the movement of which can be accompanied by strong earthquakes.

The work of seismic districting and seismic stability of structures was chiefly developed in connection with the increasing demands of construction in seismically active districts. Main efforts were directed to the further refinement of the system of seismic districting of the Soviet Union on the basis of the results of a study of the latest tectonics of the territory of the USSR and observations of seismic stations. Refinement was made in the scale for evaluating the force of earthquakes in points on the basis of instrument observations. The basis of the refined scale are the amplitudes of the relative vibrations of structures and their foundations. Considerable attention was paid, during the refinement of the maps of seismic districting, to the study of the mobility of individual sections of the earth's crust, separated by deep fractures. A beginning was made in seismic microdistricting, the main task of which is the discovery of the influence upon the nature and intensity of vibrations of the characteristics of the geologic and soil structure of the locations where the structures are erected.

The structure of the earth includes, according to seismic data, the investigation of both its deep sections as well as the crust. During the past years, a method of deep seismic sounding was developed and used widely; it is based on the correlation of waves refracted on the boundaries of the earth's crust. By means of this method, an investigation was made of the structure of the earth's core in the area of North Tyan-Shan and certain others. The characteristics of the structure of the earth's core in mountainous areas were developed. It

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was shown, in particular for North Tyan-Shan, that the layer of basalt becomes thicker under the mountains.

As regards the interior structure of the earth, a study was made of the properties of the boundary of the inner nucleus and of the boundaries of the second order in the cover of the earth. Waves were discovered which were reflected from the boundary of the inner core. It was shown that apparently the boundaries of the second order in the cover correspond to intermediate layers.

In studying seismic waves, the work was conducted in theoretical and experimental directions. The theoretical investigations were directed toward the study of the propagation of waves in plane-lamellar media. Special attention was directed to the study of the nature of the leading wave. As a result of the investigations, formulas were obtained which make it possible to determine the nature of oscillations of the leading wave as a function of the parameters of the layer medium. Considerable attention was directed to the study of interference waves(surface waves in a layer medium). In this field, general theoretical results were obtained for waves in the presence of axially symmetric sources. Of the experimental work, one should point out the investigation of the absorption of the energy of seismic waves as a result of the non-ideal elasticity. By means of ultrasonic impulse installations on the basis of stroboscopic methods, a study was made of the propagation of waves on the model; also, special attention was concentrated on the model study of the leading and surface waves.

The work toward the creation of apparatus was directed to the development of seismographs for the registration of tremors of the soil within a wide range of periods with a constant increase, and also to the creation of apparatus for the registration of very weak , near earthquakes. New types of instruments were also developed for the registration of small slopes of the earth's surface. New types of oscillographs were developed for recording the readings of several seismographs at different speeds of registration.

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Systematic investigations of microseisms were started only within recent years. The main efforts were directed to the discovery of the relationship between microseisms and their sources in connection with the passage of cyclones and storms in the ocean. Apparatus was developed for triple microseismic stations organized in accordance with the program of the International Geophysical Year(IGY).

The problem of tsunami in the USSR was started with the development only within the last 3 years. The main efforts were directed to the organization of a warning service of the possibility of tsunami during underwater earthquakes and also to the creation of a system of districting the relative danger of tsunami on the Pacific shores of the Soviet Union.

3. ANNOTATED BIBLIOGRAPHY OF WORK IN SEISMOLOGY DURING 1951-1956

GENERAL TEXTBOOKS

N. V. Veshnyakov, G. P. Gorshkov, D. P. Kirnos, A. Ya. Levitskaya, N. A. Linden, Ye. F. Savarenskiy, and D. A. Kharin. Rukovodstvo po proizvodstvu i obrabotke nablyudeniy na seymicheskikh stantiyakh SSSR(Textbook for making and processing observations on seismic stations of the USSR). Moscow. Acad. Sci. USSR, 1952.

The textbook contains information which permits the chief of the station to independently establish the work of the seismic station: to install the instruments, determine their parameters, and to make and process properly seismic observations. The book consists of three sections.

The 1st section covers information general on seismographs and the technique of registration. A description is given of seismographs for seismic stations of the general type(SGK and SVK) and for seismic stations of the regional type(GSKh and VSKh); a registration apparatus is described. The 2nd section contains information on processing close and distant earthquakes The 3rd section contains a system for the seismic districting of the territory of the USSR.

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V. T. Arkhangel'skiy, N. A. Vvedenskaya, V. N. Gayskiy, D. P. Kirnos, A. Ya. Levitskaya, I. L. Nersesov, Ya. A. Rozova, Ye. F. Savarenskiy, M. K. Chernyavkina, and D. A. Kharin. Rukovodstvo po proizvodstvu i obrabotke nablyudeniy na seysmicheskikh stantsiyakh SSSR(Textbook for making and processing observations at seismic stations of the USSR). (Part II. Textbook for processing observations of a group of seismic stations.) Moscow. Acad. Sci. USSR, 1954.

The book consists of an introduction, two chapters, and two supplements. Chapter I presents the theoretical bases of the methods used for processing the observations; original data are given on the structure of the earth's crust and times of run in different regions; the problem of the accuracy of the results of the processing ~~xxxxxxx~~ is also examined. Chapter II deals with the analysis of the results of the application of the methods of processing. The analysis is performed with concrete examples. In the selection of the examples, attention is given to the correct interpretation of the entries of the seismic waves. Supplement 1 deals with a description of the methods of installation and determination of the constants of instruments for seismic stations of the regional type. Supplement 2 examines the seismograph for recording the tremors of the earth during strong earthquakes SMR-II.

Ye. F. Savarenskiy and D. P. Kirnos. Elementy seysmologii i seysmometrii(Elements of seismology and seismometry). 2nd revised edition. Gostekhizdat, 1955.

The book covers the elements of general seismology.

The first part includes the following ch apters:

Chapter I. General information about earthquakes.

Chapter II. Elements of the theory of elasticity and the propagation of waves.

Chapter III. The influence of the earth's surface on the propagation of seismic waves.

Chapter IV. Study of the structure of the earth's crust and movements in the center of a tectonic earthquake.

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Chapter V. Innner structure of the earth on the basis of seismic data.

The second part includes the following chapters:

Chapter I. Preliminary information on stationary seismometric observations.

Chapter II. Elements of the theory of seismic instruments for direct registration.

Chapter III. Elements of the theory of seismographs with galvanometric registration.

Chapter IV. Stationary seismographs and seismoscopes.

Chapter V. Methods for determining constants.

STUDY OF SEISMISM

S. S. Andreyev, S. I. Masarskiy, D. N. Rustanovich, and D. A. Kharin. Investigation of weak earthquakes in southwestern Turkmenistan. Izv. AN SSSR, ser. geofiz(News, Acad. Sci. USSR, Geophys. Series), No. 2, 1954.

Data are described which form the basis of a map of the distribution of epicenters of weak local earthquakes in southwestern Turkmenistan as recorded by instrument observations during 1951-1952; an interpretation of the map is given.

V. I. Bune. Certain results of the study of earthquakes of Tadzhikistan during 25 years. Izv. Otd. Yestestv. nauk AN Tadzh. SSR(News, Division of Natural Sciences, Acad. Sci. Tadzhik SSR), No. 8, 1954.

The work is of a review type. It gives data on the study of the seismism of Tadzhikistan with non-instrument and seismological methods.

A contemporary map is given of the epicenters of earthquakes on the basis of data by the seismic network of Tadzhikistan during 1952, which shows qualitatively new, in comparison with previous data, ideas regarding the relationship between geological structure and seismism in the Tadzhik SSR. It is pointed out that the shortcomings of old maps is the lack of classification of earthquakes with regard to force and accuracy.

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Ye. I. Byus. Seysmicheskiye usloviya Zakavkaz'ya, ch. I. Khronologiya zemletryaseniy v Zakavkaz'i(Seismic conditions in the Transcaucasus. Part I. Chronology of earthquakes in the Transcaucasus). Tbilisi. Publishing House, Acad. Sci. Georgian SSR, 1948.

The work presents in chronological order all, known to the author, macroseismic phenomena on the territory of the Transcaucasus up to 1943.

Ye. I. Byus. Seysmicheskiye usloviya Zakavkaz'ya, ch. II. Seysmicheskiye osnovy seysmografii Zakavkaz'ya(Seismic conditions in the Transcaucasus. Part II. Seismic bases of the seismography of the Transcaucasus). Tbilisi. Publishing House, Acad. Sci. Georgian SSR, 1952.

The book deals with an examination of the seismic bases of seismography on the territory of the Transcaucasus.

The first section is a continuation of the Chronology. Seismic facts are given for the years 1944-1950.

The second section of the book is a systematic list of the points mentioned in the Chronology, with an enumeration in chronological order of all known tremors of the earth at each point, with an indication of the time of occurrence and force of underground jolts in points of the scale OST-VKS.

The third section of the book covers the seismic bases of the seismogeography of the Transcaucasus. A picture is presented of the recurrence of earthquakes stronger than two points in different locations of the Transcaucasus. The problem of the distribution of individual earthquakes and the extent of the pleistocene area. A macroseismic map is given of the maximum intensities and seismic areas of the Transcaucasus. A map is given of the distribution of the epicenters and a characterization of the main center zones revealed here.

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Ye. N. Byus. Seysmicheskiye usloviya Zakavkaz'ya. ch. III. K voprosu o khode seysmicheskoy aktivnosti v Zakavkaz'ye(Seismic conditions in the Transcaucasus. Part III. Problem of the course of seismic activity in the Transcaucasus). Tbilisi. Publishing House, Acad. Sci. Georgian SSR, 1955.

The first section examines as a first approximation the problem of the depth of occurrence of the centers of Caucasian earthquakes. For various seismically active sections of the Caucasus, there is indicated a certain predominant depth of the centers of macro-earthquakes.

The second section gives an outline of the macroseismic life of the Transcaucasus on the basis of available material. The outline is illustrated with 22 diagrams.

The third section examines the problem of the course of the seismic activity in the Transcaucasus.

Ye. N. Byus. Seismism of the Transcaucasus. Izv. AN SSSR, ser. geofiz, No. 1, 1956.

A review is given of work on the study of the seismism of the Caucasus. As a result of the completed investigations, extensive material has been collected on the seismism of the Caucasus and various conclusions have been made about the seismic activity of its individual districts.

It is pointed out that the problem of the seismotectonics of the Caucasus requires for its complete solution further study of the geological structure of the territory and of the relationship between earthquakes and concrete geological xx structures.

Ye. I. Byus and M. M. Rubinshteyn. New data on the Tabatskursk earthquakes 7-8 May 1940. Soobshch. AN Gruz. SSR(Communications, Acad. Sci. Georgian SSR), vol. XIV, No. 2, 1953.

A detailed analysis is given of the investigation of the Tabatskursk earthquake which occurred 7-8 May 1940 in the most active seismic district of Georgia - the Akh_alkalaksk Volcanic Upland.

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Ye. I. Byus and M. M. Rubinshteyn. New data on the cluster of earthquakes during 1941 in Western Georgia. Soobsh. ch. AN SSR, vol. XIII, No. 9, 1952.

An analysis is given of the processing of earthquakes of the June cluster in 1941. On the basis of this analysis, a conclusion is made regarding the existence of various deep fr cracks in the district under investigation, which confirms the assumption about the relationship between the seismic phenomena in Georgia and the continuously developing Pliocene and Postpliocene structures.

N. A. Vvedenskaya. Procedure and results of generalization of the observations of the network of stationary seismic stations in Central Asia during 1950-1953. Izv. AN SSSR, ser. geofiz. No. 6, 1954.

A discussion of the procedure and results of the generalization of the observations of the network of seismic stations in Central Asia during 1950-1953. On the basis of the plotted maps of the epicenters, a conclusion is made about the existence of a definite relationship between the distribution of the centers of the earthquakes and the geological structure of the district. A relationship is established in the distribution of the centers of weak and strong earthquakes.

G. S. Gorshkov. Seismic observations in the village of Klyuchi(from 28 August through 31 December 1948). Byull. vulk. st.(Bulletin of the Volcanological Station), No. 19, 1953.

The paper cites the resuls of a preliminary processing of seismograms of the seismic division of the Kamchatka Volcanological Station from 28 August through 31 December 1948. In accordance with the tasks of volcanology, the main attention during the observations was devoted to local jolts and particularly to the cluster of earthquakes during October and November.

G. S. Gorshkov. Seismic observations during 19491. Byull. vulk. st., No. 21, 1954.

The apparatus employed at the station in 1949 is described. A detailed list is given of earthquakes recorded by the station in 1949, with subdivision into four groups: (1) local(epicenter distance up to 75 km); (2) close(epi-

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center distances from 75 km to 600-800 km); (3) middle distant (epicenter distances from 800 to 2000 km); and (4) distant (epicenter distances over 2000 km).

G. S. Gorshkov. Seismic observations in 1950. Byull. vulk. st., No. 22, 1954.

A list is given and a brief description of earthquakes registered by the volcanological station in 1950, with their subdivision into four groups.

G. S.Gorshkov. Seismic observations in the first half of 1951. Byull. vulk. st., No. 23, 1954. The paper gives a detailed list of local and close earthquakes registered in the first half of 1951.

S. V. Yevseyev. The problem of seismism of the Ukrainian SSR, Kiev. Geologicheskiy zhurnal (Geological Journal), vol. XIV, No. 5, 1954.

An analysis is given of all existing material on the seismism of the Carpathian district of the Ukrainian SSR.

Two catalogs compiled by the author are presented: (1) earthquakes determined from instrument data and (2) earthquakes determined from macroseismic observations.

Ye. A. Koridalin, V. P. Kuznetsov, and F. A. Kirillov. The epicenters of the Shemakha earthquakes. DAN Azerb. SSR (Reports, Acad. Sci. Azerbaydzhan SSR), vol. IX, No. 12, 1953.

Data are given of the instrument study of the seismism of the epicentral zone of the Shemakh a earthquakes, which was conducted by the Institute of Physics and Mathematics of the Azerbaydzhan SSR together with the Geophysical Institute, Acad. Sci. USSR in 1951.

T. M. Lebedeva and V. G. Papalashvili. Earthquake of 12 February 1953 in the Gory District. Tr. In. geofiziki AN Gruz. SSR (Works, Institute of Geophysics, Acad. Sci. Georgian SSR), vol. XIII, 1954

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Complete processing is given of the earthquake which occurred 12 February 1953 in the Gory District.

V. P. Kuznetsov. A single characteristic of the Shemakha centers of earthquakes, which caused non-concordance in the determination of the epicenters. DAN Azerb. SSR, vol. XII, No. 9, 1956.

The propagation of seismic energy liberated during an earthquake from the Shemakha centers does not be accepted in the seismology of the system of formation of the three types of waves: P, P*, P and their corresponding $\bar{S}$, S*, S.

The Shemakha centers of earthquakes are in the sedimentary stratum. As a result of the stratification of the latter, the seismic waves undergo diffraction. Depending on the epicentral distance, the depths of the center, and the physical characteristics of the layer, the diffracted waves come first, although the distances do not exceed 60 km. For this reason, the spectrum of the seismic waves being recorded by the apparatus differs at different stations.

S. D. Makarova. Surface earthquakes in Central Asia. Tr. Uzbek. gos. un-ta(Works, Uzbek State Univ.), No. 53, 1954.

The nature of the distribution of surface earthquakes for the district of Central Asia is examined. The assumption is made that the centers of the surface earthquakes are adapted to the contact of Paleozoic and Mesozoic-Cenozoic deposits.

F. I. Monakhov. Characteristics of Afhan deep-focus earthquakes. Tr. Geofiz. in-ta AN SSSR(Works, Geophysical Institute, Acad. Sci. USSR), No. 14(141), 1952.

The paper presents the results of the determination of the depth of occurrence of the centers of certain Afghan earthquakes and of the direction of the forces acting in the centers. The determination of the depth was accomplished by the method of intersections; also, in order to facilitate the separation of phase S from the record, use was made of a year-graph of secondary waves, with evaluation of their intensity. The approximate determination of the direction of the forces in the center of the earthquake was made from the

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values of the angle of polarization of transverse waves in several points.

Besides, the paper gives data on the existence of double jolts in the centers of the earthquakes under investigation.

F. I. Monakhov and R. Z. Tarakanov. Characteristics of the Kurile-Kamchatka earthquakes during 1952-1954 from observations of close stations. An evaluation is given of the depth of the centers situated to the east of Kamchatka and the Kurile Islands.

P. N. Nikitin and Ye. V. Kutasheva. Catalog of local earthquakes in the district of the Caucasian mineral waters. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

A catalog of earthquakes in the district of the Caucasian mineral waters from data of the seismic station "Pyatigorsk" and literature sources.

S. V.Puchkov. Seismism of the territory of the Ashkhabad zone from observations in 1953. Izv. AN SSSR, ser, geofiz(News, Acad. Sci. USSR, Geophys. Series), No. 4, 1956.

Results of the work of a group of temporary seismic stations in the zone of the Ashkhabad earthquake in 1948.

As a result of the investigation, a map was was made of the epicenters of weak local earthquakes.

Ye. A. Rozova. Study of the earthquakes in Kirghizia. First scientific session, Acad. Sci. Kirghiz SSR, Frunze. Publishing House, Acad. Sci. Kirghiz SSR, 1955.

The paper points out that the seismic activity in Kirghizia has as yet been studied only slightly. There are especially little data on the seismism of its eastern section. Up to 1950 in this district as well over the entire teritory of Kirghizia, a small number of earthquakes was registered due to the small number and unfavorable distribution of the seismic stations in Central Asia. The number of earthquakes registered on the territory of Kirghizia increased considerably after the organization of seismic stations in Naryn, Przheval'sk, and Rybach'ye, but for the accurate determination of the basic seismic elements and for the solution of a whole series of other problems connected with the study of earthquakes, the existing stations are still far from sufficient.

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Ye. A. Rozova and V. P. Grin. Distribution of the epicenters of earthquakes which occurred on the territory of Kirghizia. Frunze, Publishing House, Acad. Sci. Kirghiz SSR, 1955.

Maps are given of the distribution of theepicenters of earthquakes which occurred on the territory of Kirghizia from 1929 through 1951, with an indication of the epicentral zones for certain, most seismic districts.

As an illustration of the errors which can occur in the positions of the epicenters due to incorrect interpretation of the entries of the seismic waves, a detailed processing was performed of the data on earthquakes which occurred 6 April 1953.

Ye. A. Rozova and V. G.Korolev. Seismism of the district of the city of Frunze. Izv. AN Kirgiz. SSR(News, Acad. Sci. Kirghiz SSR), No. 2, 1956.

The paper gives a list of earthquakes recorded in the district of the city of Frunze from 1929 through 1954. The maps of the distribution of the epicenters of these earthquakes indicate the main epicentral zones and their relationship with the geological structure of the district under investigation.

Ye. F. Savarenskiy. Seismism of the USSR, the results and prospects of its study. Tr. Geofiz. in-ta AN SSSR, No. 25(152), 1954.

The paper examines the problems related with the study of seismism. A system of the seismism of the USSR is given; it was compiled on the basis of data of domestic seismic stations during 1928-1948.

Ye. F. Savarenskiy. Activity of seismic stations and the tasks of Soviet seismology. Vestn. AN SSSR(Herald, Acad. Sci. USSR), No. 5, 1955.

The tasks facing Soviet seismology are described briefly.

Ye. F. Savarenskiy. Study of the seismism of difficultly accessible regions(from the program of the Internation Geophysical Year). Vestn AN SSSR, No. 6, 1956.

A description is given of the program of work in seismology which it is proposed to accomplish during the International

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Geophysical Year.

Ye. F. Savarenskiy and E. A. Dzhibladze. Seismism of the Large Caucasus. Izv. AN SSSR, ser. geofiz., No. 5, 1956.

The work gives a classification of the earthquakes in the district of the Large Caucasus with regard to the energy and a study is made of the characteristics of the geographic distribution of their epicenters.

Ye. F. Savarenskiy, N. A. Linden, and S. I. Masarskiy. Earthquakes of Turkmenistan and the Ashkhabad earthquake in 1948. Izv. AN SSSR, ser. geofiz., No. 1, 1953.

Results are given of the study of earthquakes of Turkmenistan and of observations of the Ashkhabad earthquake. These investigations were conducted on the basis of observations of the network of seismic stations of the USSR and also observations of seismic stations of other countries.

Ye. A. Sveshnikova and S. V. Yevseyev. Earthquake of 6 June 1908. Kiev, Geologicheskiy zhurnal, vol. XV, No. 2, 1955.

On the basis of instrument data of west European stations, a determination is made of the epicenters of the earthquake of 6 October 1908 and the intensity of the earthquake in the epicenter is evaluated.

A. D. Tskhakaya. Gudamarsk earthquake of 15 August 1947 (from instrument data). Kvartal'nyy seysm. byull.(Quarterly Seismic Bulletin), vol. XXI, No. 1-4, Tbilisi, 1953.

AN ANAlysis is given of the records of the first and recurrent jolts of the Gudamarsk earthquake of 15 August 1947. On the basis of instrument data, the epicenters of these two jolts were determined. Besides the seismograms of the network of seismic stations of the Acad. Sci. Georgian SSR, certain seismograms of other Caucasian stations were also used.

A. D. Tskhakaya. The problem of the seismism of the Akhalkalaksk Upland. Izv. AN SSR, ser. geofiz., No. 1, 1956.

An examination is made of the problem of the seismic activity of individual districts of the Caucasus. The district of the Alkhalkalaksk Upland is differentiated as one of the most seismic sections of the Caucasus.

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Yu. N. Yurkevich. The problem of the seismism of Transcarpathia. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

An examination is made of the problem of the seismism of the Transcarpathian Oblast of the USSR from the data of the network of Carpathian seismic stations.

PROCESSING OF SEISMIC OBSERVATIONS

S. S. Andreyev. Method of iso-surfaces in the interpretation of local earthquakes. Izv. AN SSSR, ser. geofiz., No. 2, 1954.

Two methods are presented for the interpretation of the record of local earthquakes, based on the application of fields of times. The methods are illustrated with examples of the processing of weak earthquakes registered in the southwestern Turkmenistan.

V. M. Arkhangekl'skaya. Use of a [illegible] new-type wave in the determination of the azimuth of the epicenter of a close earthquake., Izv. AN Turk. SSR(News, ACad. Sci. Turkmen SSR), No. 5, 1954.

The author discovered on the records of close and local earthquakes a long-period wave which enters 2-3 seconds after the entry of the wave P and he designated it wave A. The period of the wave A varies from 2-3 to 7 seconds. By the x shape of the oscillations, the wave suggests surface waves. The movement of the particles of the earth's surface during the passage of the wave A takes place in a vertical plane oriented to the epicenter. The relatively large period of the wave A, in comparison with the wave P, determines the much higher accuracy of the determination of the azimuth, inasmuch as the influence of the heterogeneities of the earth's core on the twisting of the seismic ray of this wave will be the least.

V. M. Arkhangel'skaya. The determination of the direction to the epicenter of the earthquake from the records of surface

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waves of distant earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

A method is presented for the well-defined determination of the direction to the epicenter from the records of surface waves of distant earthquakes with a non-deep occurrence of the center. Examples are given of the determination of the azimuth. The accuracy of the determination of the azimuth from surface waves is up to ±1—2°, which is of practical significance in the seismic service.

Yu. G. Balashko. The problem of the methods of processing close earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 20(147), 1953.

A brief review is given of the methods of processing close earthquakes. The methods are classified and the possibility of their practical utilization is examined.

V. I. Bune. Classification of earthquakes with regard to the energy of the elastic waves emitted from the center. DAN Tadzh. SSR(Reports, Acad. Sci. Tadzhik SSR), No. 14, 1955.

A scale is given for the classification of the earthquakes of Tadzhikistan with regard to th eir force, based on the index of distance of registration.

V. I. Bune. Classification of earthquakes with regard to their force on the basis of instrument data. Izv. AN SSSR, ser. geofiz., No. 1, 1956.

A scale is proposed for the classification of earthquakes with regard to their force--the amount of energy emitted from the center in the course of the earthquake. A concrete example is given for the preparation of a scale for the classification of the earthquakes of Tadzhikistan from data in the Bulletin of the Seismic Network of the USSR. A method is proposed for the evaluation of the energy of an earthquake from the records of close stations, based on a comparison of the general nature of the records of the given earthquake with the genral nature of the record of an earthquake typical for the given class for a definite epicentral distance.

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Ye. M. Butovskaya. The wave P*S in close earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 16(143), 1952.

The paper examines the problem of the propagation of a transverse wave resulting from a longitudinal wave running under a layer of granite. Such waves are observed at the station "Tashkent" during earthquakes which occur in Central Asia.

N. A. Vvedenskaya. The accuracy of determination of the position of the center of earthquakes by the method of intersections. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

The method of the fields of times is used to solve the problem of the evaluation of the accuracy of determination of the position of the centers of earthquakes by the method of intersections. On the basis of derived formulas, a dependence has been established between the accuracy of determination of the position of the center and the type of waves being utilized, distribution of the seismic station and accuracy of reading of the difference of times of arrival of the longitudinal and transverse waves at the seismic stations.

N. A. Vvedenskaya. The generalization of observations of stationary seismic stations of Central Asia. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

The procedure for determining the position of the centers of earthquakes is examined in compiling the bulletin of stationary seismic stations of Central Asia.

N. A. Vvedenskaya. Separation of the wave sP on the records of deep earthquakes of Central Asia. Tr. Geofiz. in-ta AN SSSR, No. 36(163), 1956.

A discussion of the problem of the separation of the reflected-diffracted wave sP on the records of deep earthquakes for small epicentral distances. The possibility and expedience of using the wave sP for determining the depth of the center is shown.

V. N. Gayskiy. The problem of processing close earthquakes Tr. Geofiz. in-ta AN SSSR, No. 20(147), 1953.

A graphical method is presented for determining the epicenter of a close earthquake, related with the plotting of epicenters. The variable parameter is the difference of the

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initial ordinates of the year-graphs of fictitious waves.

The proposed method makes it possible to reliably process well-recorded earthquakes, without making any preliminary assumptions except the assumption of the linearity of the year-graph.

V. N. Gayskiy. The accuracy of determining the position of the center and the elements of the structure of the earth's crust. Tr. Geofiz. in-ta AN SSSR, No. 22(149), 1954.

An examination is made of the problem of accuracy of processing normal, close earthquakes by objective methods which utilize only the assumption of the linearity of the year-graph. On the basis of contemporary requirements for the accuracy of observations($\pm$ 1 sec), an evaluation is given of the possible errors in determining the position of the epicenter, depth of center, velocities of elastic waves, and thickness of layers of the crust. An investigation is made of the magnitude of the above-indicated errors as a function of the type of waves being used and the number of stations.

V. N. Gayskiy and V. N. Bichevina. Interpretation of observations of close earthquakes. Tr. Geofiz. in-ta AN SSR, No. 21(148), 1953.

A method is described which makes it possible to reveal uniform phases on the records of close earthquakes.

Ye. I. Gal'perin. Azimuth method of seismic observations. Moscow, State Scientific-Technical Publishing House of Petroleum and Mining-Fuel Literature, 1955.

The brochure describes a new azimuth method of seismic observations. The method is applicable in seismic surveying and seismology determining the direction of the vector of displacement the earth and analysis of the type of waves on the seismograms from the nature of their polarization. Problems of the theory of the method are examined. A description is given of azimuth installations. A procedure is presented for observations and processing of seismograms. The brochure is intended for scientific workers, engineers, and technicians--seismic surveyors.

G. A. Gamburtsev. New type of phase correlation in seismic observations. DAN SSSR(Reports, Acad. Sci. USSR),

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vol. LXXXVII, No. 1, 1952.

Considerations are presented in support of azimuth correlation of seismic waves and its basic characteristics are also indicated. It is emphasized that the methods of azimuth correlation can find application in the solution of various important problems in seismology: the study of migration of centers of earthquakes, the determination of dynamic characteristics of centers, the study of the seismism of individual tectonic structures, etc.

G. A. Gamburtsev. The determination of the azimuth on the epicenter during the registration of local earthquakes. DAN SSSR, vol. LXXXVII, No. 2, 1952.

Emphasis is placed on the advantages of the correlation methods of registering earthquakes in the determination of the azimuth on the epicenter of local earthquakes in districts having a complex geology.

G. A. Gamburtsev. Correlation methods of studying earthquakes. DAN SSSR, vol. XCII, No. 4, 1953.

Note is made of the significance of the use of correlation principles in the solution of problems of seismology. The merits of special seismic stations are pointed out.

S. I. Golenetskiy. Method of pseudohyperbolas. Tr. Geofiz. in-ta AN SSSR, No. 16(143), 1952.

A method is proposed for determining the position of the epicenter of distant earthquakes. The method is based on the use of the difference of the absolute moments of the entries of the phase P at several stations. It is applicable for the determination of the epicenters of normal as well as deep earthquakes.

S. I. Golenetskiy. Analy tic method of processing deep earthquakes from the year-graph. Tr. Geofiz. in-ta AN SSR, No. 20(147), 1953.

A calculation system is described for the analytic processing of deep earthquakes from the year-graph by the method of least squares.

S. I. Golenetskiy. Determination of the epicenter of a close, deep earthquake. Tr. Geofiz. in-ta AN SSSR, No.

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No. 20(147), 1953.

An analysis is given of the year-graphs of Central Asiatic deep earthquakes through the determination of the epicenters for these earthquakes by the method of isochrones and hypocenters.

S. I. Golenetskiy and A. A. Treskov. Method of isochrones. Tr. Geofiz. in-ta AN SSSR, No. 21(148), 1953.

A new method is proposed for determining the epicenter of a close earthquake from the data of four or more stations.

The method of isochrones postulates the linearity of the year-graph on limited sections but no assumption is made about the apparent velocity.

S. I. Golenetskiy and V. N. Gayskiy. Two mechanisms for the graphical processing of observations on close earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

Designs of mechanisms are described which facilitate the graphical processing of observations on close earthquakes.

S. Ye. Yevseyev. The problem of determining the elements of close earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 22(149), 1954.

Two methods are presented for determining the seismic elements of close earthquakes.

S. I. Yeres'ko. Investigation of errors in determining the position of the centers of Crimean earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 36(163), 1956.

An evaluation is given of the accuracy of determination of the position of the epicenter and depth of occurrence of the center of earthquakes by the method of Vadati.

N. K. Karapetyan. Year-graph of seismic waves of Little Caucasus. Izv. AN SSSR, ser. geofiz., No. 1, 1956.

On the basis of observations of Caucasian stations during recent years, a year-graph was plotted for the district of Little Caucasus. The year-graph has small deviations from the year-graph by A. Ya. Levitskaya and T. M. Lebedeva.

V. I. Keylis-Borok and S. D. Kogan. The problem of determining the azimuth on the epicenter. Tr. Geofiz. in-ta AN SSSR, No. 14(141), 1952.

The paper presents a method for determining the azimuth on

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epicenter from the displacements in transverse waves. The results can be utilized also for the determination of the angle of exit, for checking the correctness of interpretation of the phases, and for determining the azimuth on the epicenter from longitudinal waves in case of absence of one of the horizontal components.

The described method was used to determine the azimuth on the epicenter for 9 cases. Comparison with azimuths, obtained from a longitudinal wave and by geometric calculation, shows that it is possible from the transverse wave to determine the azimuth on the epicenter almost with the same accuracy as from the longitudinal wave.

S. D. Kogan. The application of the principle of phase correlation to distant earthquakes. DAN SSSR, vol. 101, No. 4, 1955.

Experience in phase correlation of distant earthquakes is recounted. The results of the work show that the correlation of distant earthquakes possibly improves the basis of interpretation and makes it possible to select reliable initial data not only among the distinct but also among the weak entries.

M. N. Kolosenko. Determination of the azimuth on the epicenter of a distant earthquake from the moments of entry of the seismic wave at two stations. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

The paper deals with the problem of determining the position of a distant earthquake from the azimuth obtained by the differential(kinematic) method.

The problem is presented and also its solution in a plane and spherical cases; an evaluation is made of the error of determination of the azimuth and conditions are determined which assure an accuracy of up to ±1°; formulas are recommended and a nomogram which reduce the necessary calculations;

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examples are cited for determining the position of the epicenter of several earthquakes. The described method is essentially useful for a unilateral distribution of seismic stations with respect to the epicenter.

N. V.Kondorskaya. Separation of the wave sP for non-deep earthquakes and its utilization for the determination of the depth of the center. Tr. Geofiz. in-ta AN SSSR, No. 36(163), 1956.

It is shown that it is possible to separate waves reflected near the epicenter(sP and sS), on the records of earthquakes the centers of which are situated in the earth's crust, for epicenter distances of 2 to 80°. The existence of a sufficiently intensive wave sP for non-deep earthquakes is established as a result of the examination of the dynamic characteristics of the wave sP, related with the mechanism of the center of earthquakes.

A method is pointed out for determining the depth of occurrence of the center of an earthquake situated in the earth's crust, on the basis of differences of times of the arrival of the waves sP and P; sPP and PP; sPPP and PPP,; sS and S.

S. I. Kosenko. The problem of the calculation of the energy of earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 21(148), 1953.

The work investigates the problem of the evaluation of the energy of earthquakes from the observations of seismic stations. Two problems are examined: (1) calculation of the total energy for a normal, distant earthquake from the surface waves; (2) clarification of the distribution of the energy of space waves as a function of the direction of emission

F. I. Monakhov. Certain results of an analysis of the Earthquakes of the Garm oblast. Izv. AN SSSR, ser. geofiz., No. 2, 1953.

An examination is made of the problem of determining the position of the center of the earthquake from observations of seismic stations with epicenter distances of 100-800 km. An analysis is made of the earthquake in the Garm oblast of

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the Tadzhik SSR, which occurred in 1949-1950.

A. Ya. Levitskaya and T. M. Lebedeva. Year-graph of the seismic waves of the Caucasus. Tbilisi. Kvart. seysm. byull. vol. XXI, No. 1-4, 1953.

A preliminary year-graph is given of the seismic waves of the Caucasus for a depth of earthquake centers of 25 km; it was plotted on the basis of instrument observations of Caucasian seismic stations from 1933 through 1950. Macroseismic data of certain strong Caucasian earthquakes were also used in the preparation of the year-graph.

I. L. Nersesov and L. N. Rykunov. Processing of local earthquakes of the Garm Oblast. Tr. Geofiz. in-ta AN SSSR, No. 21(148), 1953.

The paper presents amethod of processing local earthquakes; it takesinto account the heterogeneity of the medium in a horizontal direction, by modifying the methods of Vadati and Isikawa. The methods are applied to the processing of earthquakes of the Garm Oblast, which were recorded in 1950 by the network of seismic stations of the Garm Expedition of the Geophysical Institute.

Ye. A.Rozova. Year-graphs for close deep-focus earthquakes of Central Asia. Izv. AN Kirghiz. fil. AN SSSR(News, Kirghiz Branch, ACAD. Sci. USSR), No. 3(13), 1954.

The work deals with an analysis of year-graphs for deep-focus earthquakes of the district of Central Asia. The graphs were prepared by N. A. Vvedenskaya, F. I. Monakhov, and Ye. A. Rozova.

Ye. F. Savarenskiy. The determination of the moment of occurrence from the moments of entry of diffracted waves. Tr. Geofiz. in-ta AN SSSR, No. 16(143), 1952.

The work describes and illustrates a method of determining the position of the epicenter of an earthquake, based on the difference of times of entry of diffracted waves at various stations.

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Ye. F. Savarenskiy. The determination of the moment of occurrence of an earthquake from the moments of entry of the waves $\breve{P}$ and $\bar{S}$. Tr. Geofiz. in-ta AN SSSR, No. 16(143), 1952.

The paper describes a method for determining the moment of occurrence of an earthquake; it does not require knowledge of the velocities of propagation of seismic waves and the structure of the earth's crust.

Examples of the application of this method are given.

Ye. F. Savarenskiy. Distortions on seismism maps. Izv. AN SSSR, ser. geofiz., No. 7, 1956.

An examination is made of the problem of distortions intoruced into seismism maps by the non-uniform distribution of seismic stations, improvement and increase in their number during the period under investigation. As an illustration, the seismism map of the Caucasus during 1952-1953 is examined.

Ye. F. Savarenskiy and V. S. Nekilina. Consideration of geological heterogeneities in determining the position of the center of an earthquake. Izv. AN SSSR, ser. geofiz., No. 1, 1955.

Methods are examined for determining the position of the center of an earthquake for constant velocities within planar-parallel horizontal lay ers of the earth's crust. A specific method is proposed for taking into account geological heterogeneities. This method is applicable to certain observations made in 1951 by regional-type stations of the Aral-Caspian Expedition of the Acad. Sci. USSR.

S. L. Solov'yev. Classification of earthquakes from the magnitude of their energy. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

The most simple methods are described for evaluating the energy of earthquakes; these methods are at present in use; an approximate energy characterization of earthquakes in Turkmenistan during 1912-1951 is given and the problem is posed about the processing the energy scale for the classification of earthquakes.

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A. A. Treskov and S. I. Golenetskiy. Method of hypocenters. Tr. Geofiz. in-ta AN SSSR, No. 14(141), 1952.

A graphical method is proposed for the joint determination of the position of an epicenter and depth of center of a distant earthquake. This method can be used in processing the data of a group of seismic stations.

D. A. Kharin, V. I. Keylis-Borok, and S. D. Kogan. A procedure of seismic observations in the epicenter zone and their interpretation. Tr. Geofiz. in-ta AN SSSR, No. 21(148), 1953.

The paper presents the results of an experimental-methodical expedition of the geophysical institute for the study of the epicenter zone in the Garm Oblast and also attempts to determine the dynamic characteristics of the centers by the method developed by V. I. Keylis-Borok.

The basic results come to the following: (1) separation of the epicenter zones, (2) establishment of the type of faults and the determination of their orientation.

The observations made it possible to make various methodical conclusions pertinent to the investigated epicenter zones.

D. A.Kharin and S. I. Masarskiy. Investigation of the epicenter regions by means of regional seismic stations. Tr. Geofiz. in-ta AN SSSR, No. 25(152), 1954.

The paper contains a brief review of investigations of different epicenter regions, which were conducted by the Geophysical Institute in 1949-1950.

The paper shows that the study of earthquakes with small epicenter distances($\Delta < 100$ km) involves specific requirements of apparatus and also procedure and performing and interpreting observations.

M. K. Chernyavkina. Evaluation of errors in the determination of the epicenters of successive jolts of the Chatkal'sk earthquake. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

An examination is made of the relationship between the distribution of the epicenters of successive jolts of the Chatkal'sk earthquake of 2 November 1946 with the basic

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tectonic structures of the district and an investigation is made of the accuracy of determination of the position of the epicenter from data of seismic stations. The maximum possible error in the determination of the position of the epicenter, for the most unfavorable distribution of stations, has been determined.

N. V. Shebalin. The relationship between the energy, points, and depth of center of earthquakes. Izv. AN SSSR, ser. geofiz., No. 4, 1955.

The work deals with the problem of the evaluation of the force of shock on the earth's surface(points) from the magnitude of the energy of the earthquake and the depth of the center, as determined from instrument data.

An examination was made of 56 earthquakes with a depth of centers from 5 to 640 km. The energy was determined by the method of B. Guthenberg and K. Richter("Seismism of the Earth", 1949). Displacements in surface waves were utilized.

As a result, a relationship between the energy and points was obtained in the following form:

$$N=0.9\ni-\gamma'(h) \qquad (\ni=\lg E \text{ megajoules})$$

with the parameter $\gamma'(h)$ depending on the depth of the center.

For earthquakes with a depth of center from 5 to 70 km, the following equation of the parameter $\gamma'(h)$ was obtained:

$$\gamma'(h)=0.9\ni - N=3.8 \lg h-3.3.$$

In passing from centers with a depth of 60-70 km to centers with a depth of 80-100 km, there is a sharp decrease in $\gamma'(h)$, approximately of the order of two and one-half times. For deep earthquakes, the equation for $\gamma'(h)$ has the form of

$$\gamma'(h)=3.1 \lg h-4.4.$$

In the opinion of the author, the observed jump in the difference of $0.9\ni-N$ is explained by the sharp variation in the intensity of the surface waves at the expense of the screening action of the layer of reduced velocity at a depth of 80 km.

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CONDITIONS AND CAUSES OF EARTHQUAKES

V. F. Bonchkovskiy. Slopes of the earth's surface as one of the possible forerunners of earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 25(152), 1954.

Factual data are cited which show the complexity of the process of the variation of slopes and, in certain cases, their non-identity even in two adjacent points. It is shown that the slope meters themselves are sufficiently accurate instruments which reflect well the true movements of the earth's surface. From a comparison of data on slopes and perceptible earthquakes, a general conclusion is made regarding the occurrence of ~~of~~ particularly numerous storms of slopes during a period of seismic activity of the district under study and a comparatively smooth course of slopes during seismically quiet periods. It is pointed out that there are still no reliable prognostic signs of earthquakes, based on observations of the slopes of the earth's surface.

A. V. Vvedenskaya. The determination of the dynamic parameters of the centers of earthquakes from the observations of distant stations. DAN SSSR, vol. XXX, No. 4, 1951.

The paper examines the problem of the determination of the dynamic parameters of the center(nature of fault, orientation of surfaces of faults, directions of acting forces) from the observations of distant stations. Moreover, the allowance is made that the center of the earthquake is equivalent to double force with the moment. A system is proposed for determining the parameters of the centers. This system was used to determine the parameters of the centers of four earthquakes on the territory of the USSR.

A. V. Vvedenskaya. The problem of the dynamic [redacted] characterization of the centers of distant earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 20(147), 1953.

An examination is made of the problem of determining the dynamic parameters of the center(nature of fault, [redacted]

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orientation of surface of fault, directions of acting forces) from observations of distant stations. The determination was made on the basis of an allowance of the equivalence of the center of the earthquake to a double force with a moment.

A. V. Vvedenskaya. The application of the Wolf network in the determination of the dynamic parameters of the centers of earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 20(147), 1953.

The application of the Wolf network in determining the parameters of the source, equivalent to the center of the earthquake, is examined.

A. V. Vvedenskaya. The determination of fields of displacements in earthquakes by means of the theory of dislocations. Izv. AN SSSR, ser. geofiz., No. 3, 1956.

In order to determine the fields of displacements of the space waves of earthquakes, use is made of the equations of the theory of dislocations, which are first integrated. By means of the resulting formulas, the axes of the main stresses and the positions of the surfaces of slipping in the center are determined. Formulas are proposed for the approximate evaluation of the dimensions of the center.

G. A. Gamburtsev. Condition and prospects of activities in the field of forecasting earthquakes. Byull. Soveta po seysmologii (Bulletin of the Council on Seismology), No. 1, 1955.

In the light of ideas on the mechanism of the center of earthquakes, it can be assumed that a strong earthquake can be preceded by such phenomena as gradual tremors of the earth's crust, variation in the seismic condition, appearance of deformations on the earth's surface, variation of electrical and magnetic fields, and certain others.

Until now it has not yet been possible to obtain positive or negative results from any one of these factors. However, on the basis of completed work, the notion developed about greater or lesser prospects of the different directions of the investigation.

The most promising is the study of long-period vibrations of the earth's crust. A second promising direction is the study of the seismic condition.

V. I. Keylis-Borok. Graphical methods of the

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calculation of the dynamic parameters of the center of an earthquake. Izv. AN SSSR, ser. geofiz., No. 6, 1951.

Graphical methods are examined for the determination of the parameters of the source, approximately equivalent to the center of the earthquake.

V. I. Keylis-Borok. The problem of the relationship of point and space sources. Izv. AN SSSR, ser. geofiz., No. 4, 1956.

An examination is made of the conformance between point sources, used in the determination of the dynamic parameters of the center of an earthquake, and space sources with a different distribution of forces or initial disturbance.

V. I. Keylis-Borok and A. V. Vvedenskaya. Investigation of stresses in the centers of the Khaitsk epicenter zone. Tr. geofiz. in-ta AN SSSR, No. 25(152), 1954.

A mass determination was made of the dynamic parameters of the centers of a group of close earthquakes in the Pamir foot hills. The most convenient system of interpretation is mapped out. The regularities in the nature and orientation of the dislocations in the centers are projected and compared with the tectonic data.

S. D. Kogan. The problem of the study of the mech anism of deep earthquakes. DAN SSSR, vol. XCIX, No. 3, 1954.

The determination of the dynamic parameters of the centers of deep earthquakes of the Pacific Ocean and Central Asia is examined.

The results obtained on the basis of processing of various Pacific and Cental Asian deep earthquakes are briefly presented.

S. D. Kogan. Dynamic parameters of the centers of deep earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

The work deals with the determination of the dynamic

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parameters of the centers of deep earthquakes of the Pacific Ocean and Central Asia. The first paragraph gives a resume of the history and status of work in the study of the mechanism of earthquakes. The second paragraph deals with the procedure of interpretation of observations. A method is proposed for the utilization of reflected waves; an examination is made of the possibility of phase correlation of the earthquakes under study and various other methodical problems. The third paragraph gives the experience and results of the study of deep earthquakes.

S. D. Kogan. The determination of the dynamic parameters of the centers of earthquakes approximately equivalent to the combined sources. Izv. AN SSSR, ser. geofiz., No. 5, 1956.

An investigation was made of the signs and ratios of the displacements in longitudinal and transverse waves for the case of combined sources equivalent to the sum of the individual sources. The results make it possible to use, in the case of combined sources, the method of V. I. Keylis-Borok, while retaining the general system of interpretation.

S. D. Kogan and L. N. Malinovskaya. Transparent sheets for the determination of the dynamic parameters of the centers of earthquakes. Izv. AN SSSR, ser. geofiz., No. 2, 1953.

Transparent sheets are proposed for the determination of the dynamic parameters of the centers of earthquakes by the method of Keylis-Borok; these also make it possible to evaluate the accuracy of interpretation and select the optimum system of original data.

L. N. Malinovskaya. Procedure for determination of the mechanism of earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 22(149), 1954.

The most rational and practical procedure is developed for the determination of the dynamic parameters of the centers of earthquakes from the records of straight longitudinal and transverse waves. Nomograms are proposed and transparent sheets for the graphical solution of the original equations, methods of joint interpretation of the signs of longitudinal and transverse waves, method for the determination of the axis of the center

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of rotation, etc.

A complete system is described for the interpretation with consideration of the experience of processing of observations.

L. N. Malinovskaya. Dynamic characterization of the centers of south-western Turkmenistan. Izv. AN SSSR, ser. geofiz. No. 1, 1955.

Results are cited of the determination of the dynamic parameters of the centers of 27 weak earthquakes of south-western Turkmenistan, registered by the network of stations of the Aral-Caspian Expedition of the Geophysical Institute, Acad. Sci. USSR in 1951 and 1952.

G. P. Tamrazy an. Earthquakes in the Kazbek district and elastic inflows (incoming tides). Izv. AN SSSR, ser. geofiz., No. 7, 1956.

The question is examined of the relationship between earthquakes of the Kazbek district with the cosmic conditions of the planet, in particular with incoming tides caused by the moon. On the basis of a comparison of seismic data with the phases of the moon, it was established that the number Kazbek earthquakes increases with the presence of the earth under cosmic conditions favorable for earthquakes (new moon or full moon and perigee) and descreases sharply with the presence of the earth under the least favorable cosmic conditions (first or last quarter and apogee).

G. P. Tamryazan. Regularities in the distribution of the earthquakes of Turkmenistan and certain problems of the prognosis of earthquakes. Izv. AN Turkm. SSR (News, Acad. Sci. Turkmen SSR), No. 5, 1956.

On the basis of a study of the earthquakes of Turkmenistan during 1917-1951 in connection with the cosmic conditions of our planet, the following regularities are revealed: with decreasing interval of time between the perigee of the lunar orbit and the nearest syzygy, the number of strong earthquakes in Turkmensitan increases sharply.

About 98% of the entire seismic energy of the cores of Turkmenistan was liberated during perigee-syzygy time intervals particularly favorable for earthquakes.

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SEISMIC DISTRICTING AND SEISMIC RESISTANCE OF STRUCTURES

O. S. Berlyand. The problem of the action on construction elements of loads which last a short time interval. Tr. Geofiz. in-ta AN SSSR, No. 16(143), 1952.

The work examines the action of a brief(with respect to the first tones of the natural vibration) load on a beamof constant cross section with both ends h inge-supported. It is assumed that the load varies sinusoidally with time and acts within the limits of half period.

Formulas are cited for the displacement of the bending momentand the cross-cutting force in the case of a concentrated and uniformly distributed load for a beam hinge-supported at both ends.

An investigation is made of the resonance for the high-frequency force given in the form of an odd number of sinusoidal half waves with one of the highest harmonics, with and without viscosity.

V. A. Bykhovskiy. Experience in the solution of certain problems of the seismic resistance of building and engineering structures by the experimental investigation of their space models. Yerevan. Tr. koord. soveshch . po seysm. stroitel'stvu(Works, Coordination Conference on Seismic Construction), 1956.

The work describes experimental investigations carried out with the simplest space models of thejunctions of brick walls of certain types of hydrotechnical structures of massive construction and earth dam. Altogether, 279 models were tested and 760 experiments were conducted. The completed investigations made it possible to arrive at various important conclusions regarding the problems of seismic resistance of buildings and engineering structures.

N. V. Veshnyakov. Quantitative evaluation of the force of earthquakes. Izv. AN SSSR, ser. geofiz., No. 3, 1955.

Existing methods of evaluating the force of an earthquake at the point of observation are examined. A suggestion is introduced and supported for determining the force or intensity of an earthquake from the maximum density of the energy of the seismic waves in rocks wh ich

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lie on the earth's surface and to express it in joules per $m.^3$

N. N. Kalinina. The determination of accelerations during earthquakes by means of a mathematical pendulum. Izv. AN Kaz. SSSR, ser. matem. i mekh(News, Acad. Sci. Kazakh SSR, Math. and Mech. Series), No. 5, 1951.

The problem is posed for the determination of the earth's acceleration during an earthquake from the angle of the least deviation of the mathematical pendulum in its inertial movement.

Formulas are derived for the determination of the acceleration of a point of the pendant of the pendulum in case its acceleration is directed horizontally or at an angle.

By means of the cited formulas, determination was made of the acceleration of the earth's surface during the Ashkhabad earthquake.

B. K. Karapetyan. Method of determining the reduced seismic accelerations. Izv. AN Arm. SSR(News, Acad. Sci. Armenian SSR), vol. VII, No. 1, 1955.

A method is shown for determining reduced seismic accelerations; it is based on the processing of accelerograms which show the directly recorded acceleration of the ground. With the reduced seismic accelerations, it is possible to easily calculate the force of inertia in buildings as a function of time.

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B. K. Karapetyan. Experience in the application of seismometers AIS for the registration of seismo-explosive waves. Yereva. Tr. koord. soveshch. po seysm. stroitel'stvu, 1956.

The latest-design of seismometer AIS is described. On the basis of seismometric observations conducted in 1953, various conclusions are made about the application of seismometers for the registration of seismo-explosive waves. The directions of further investigations are mapped out.

B. K. Karapetyan and L. V. Shakhsuvaryan. Results of an engineering examination of the Byurakan earthquake, Izv. AN Arm. SSR, vol. VII, No. 5, 1954.

The paper contains certain results of the engineering investigation of the Byurakan earthquake which occurred 3 June 1949, at 10 hrs. 24 mins. local time. On the basis of a generalization of the results of the investigation, the conclusion is made that, for the most part, buildings made of small rubblstone and clay mortar were damaged.

A. Z. Kats. The problem of the consideration of ground conditions during seismic microdistricting. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

The paper examines the problem of the influence of ground conditions on the intensity of seismic vibrations in points of the earth's surface. It is shown that, for the evaluation of the relative variation of the intensity of seismic vibrations in the epicenter districts, one can start with the conditions of the normal drop of the seismic waves.

A. Z. Kats. Procedure of measurement of dynamic deformations in soils and buildings. Tr. Geofiz. in-ta AN SSSR, No. 36(163), 1956.

A procedure is described and also experience in the measurement of deformations in soils and buildings.

A. Z. Kats and S. V. Puchkov. The effect of seismic waves on buildings. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

The paper presents the results of an instrument study of the vibrations of buildings caused by earthquakes and explosions. The correlation of the amplitudes of vibrations for the phases P and S and their variation during passage from the ground to the elements of buildings. The characteristic

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vibrations of the ground are revealed and their intensity in comparison with the vibrations in other phases is pointed out. Data were obtained on the influence of the medium in which the source is situated upon the intensity of vibrations at the point of observations.

I. L. Korchinsky. Design of buildings against seismic effects. Moscow. State Publishing House of Building and Architectural Literature. 1954.

The brochure presents a method for determining seismic forces; it is based on an analysis of the results of destruction caused by earthquakes and on an analysis of seismograms of earthquakes. The recommended method for the determination of seismic forces takes into account the form and frequency of natural vibrations of buildings, which were previously not taken into consideration and which have substantial practical significance. Comparative calculations conducted in accordance with this procedure have shown better agreement of the results with data of experiments, in comparison with the method heretofore used.

Recommendations are made for the determination of horizontal seismic forces and examples are given of the calculation(design) of three types of buildings. The brochure is intended for building engineers and scientific workers engaged in problems of seismo-resistant building.

S. V. Medvedev. Evaluation of seismic points as a function of ground conditions. Tr. Geofiz. in-ta AN SSSR, No. 14 (141), 1952.

The work examines problems of the influence of ground conditions on the intensity of seismic effects. Examples are given of the determination of the increment in seismic points and certain premises for performing seismic districting are demonstrated.

S. V. Medvedev. Seismic observations in the course of seismic microdistricting. Byull. Soveta po seysmologii, No.1, 1955.

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The Turkmen Expedition of the Geophysical Institute of the Acad. Sci. USSR made measurements of vibrations during earthquakes on sections with different conditions in the district of Ashkhabad. Measurements were also made of the vibrations of buildings during earthquakes. Instrument measurements gave results in agreement with that shown by the study of destructive after-effects of the earthquake of 1948. The forms of non-stationary vibrations at different stations within the city limits are not identical, which indicates the need of spectral analysis of the seismic vibrations of the ground. The observations point out that the ~~influence~~ intensity of the vibrations is influenced not only by the ground conditions but also by the characteristics of the medium through which the waves propagate from the center. This is important for developing systems of seismic microdistricting.

S. V. Medvedev. New seismic scale. Tr. Geofiz. in-ta AN SSSR, No.21(148), 1953.

A new seismic scale is published. It was prepared by the author and is intended for determining the force of an earthquake at the point of observation. The principles of the new scale are outlined and the materials which served as its basis are pointed out.

S. V. Medvedev. Vibration of the vertical system during horizontal seismic effects. Tr. Geofiz. in-ta AN SSSR, No. 36(163), 1956.

The work clarifies the characteristics of the vibrations of a building in the light of a vertical cantilever system. For a quantitative evaluation of the effect of an earthquake on a structure, it is proposed to use the action spectrum.

S. V. Medvedev. The dependence of seismic effects on the periods of natural vibrations of buildings. Tr. Geofiz. in-ta AN SSSR, No. 36(163), 1956.

The work presents procedures for the determination of the action spectrum of seismic vibrations on buildings from the records of seismic stations and the values of the determined spectral coefficients are given.

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S. V. Medvedev. The influence of forces of inner friction on the vibration of buildings during earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 36(163), 1956.

An examination is made of the problem of the influence of forces of inner friction, which occur in buildings and their foundations during seismic actions, on the magnitude of the amplitudes of vibrations in the course of the earthquakes.

S. V. Medvedev. Seismometer for the determination of the points(measurement) of earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 36(163), 1956.

The paper contains a description and procedure of installation, adjustment, and operation of the seismometer SBM developed by the author.

S. V. Medvedev. Preparation of an atlas of strong earthquakes on the territory of the USSR. Yerevan. Tr. koord. soveshch. po seysm. stroitel'stvu, 1956.

Priniciples are given for the preparation of an atlas of strong earthquakes. Examples are given of maps of isoseists for three earthquakes, which were prepared by the author on the basis of an expeditionary investigation of earthquakes.

S. V. Medvedev and A. G. Nazarov. Basic directions of investigations of the seismic resistance of structures. Yerevan. Tr. koord. soveshch. po seysm. stroitel'stvu, 1956.

Investigations in the field of seismic resistance of structures include the following divisions: (1) seismic effects on structures, (2) characteristics of constructions and materials during seismic effects, (3) the search for measures to assure the preservation of structures during strong earthquakes.

The main topics pertaining to each of the three divisions of the investigations are delineated.

A. G. Nazarov. Principles of seismic resistant construction. DAN Arm. SSR(Reports, Acad. Sci. Armenian SSR, vol. XVII, No. 2, 1953.

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Summary of the basic rules of seismic resistant construction is given in a compact form.

A. G. Nazarov. Seismic districting. Izv. AN Arm. SSR, vol. VII, No. 1, 1954.

It is shown in the work that (1) available maps of the seismic districting of individual seismic districts of the USSR can lead to inaccurate results during seismic microdistricting.

(2) Seismic districting can be accomplished on th e assumption that all the territory under consideration is entirely equal with respect to soil and morphological conditions.

A. G. Nazarov. A new seismic scale. Izv. AN Arm. SSR, ser. fiziko-matem., yestestvennykh i tekhnicheskikh nauk (News, Acad. Sci. Armenian SSR, Series of Physico-Mathemat., Natural, and Technical Sciences, vol. 7, No. 3, 1954.

The paper deals with a detailed analysis and critique of the new seismic scale GOST 6249-52 which was made effective 1 January 1953.

The necessity of mass application of multi-pendulum seismometers with hysteresis damping for the evaluation of the intensity of an earthquake is emphasized.

A. G. Nazarov. Equations of the theory of seismic resistance with consideration of the scattering of energy. DAN Arm. SSR, vol. XVIII, No. 3, 1954.

Equations are set up for the vibrations of buildings under the influence of seismic waves. A method is proposed for solving these equations; it is based on the application of the maximum multi-pendulum seismometer AIS-2. The design of the seismometer AIS-2 is described.

A. G. Nazarov. Method of engineering analy sis of seismic forces. Yerevan, Publishing House, Acad. Sci. Armenian SSR. 1956.

An evaluation is made of the force of an earthquake on the basis of the spectral curve of reduced seismic accelerations. An examination is made of the development of a simplified

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instrument for the direct recording of reduced seismic accelerations. The designs of multi-pendulum seismometers are described and also experience of their application for the evaluation of seismo-explosive waves.

The work pays much attention to simplified procedures for the utilization of spectral curves having independent significance for the evaluation of the stressed condition of a building and for the solution of various problems of engineering seismology.

A. G. Nazarov. Prospects of research work in the field of engineering seismology in the Armenian SSR. Yerevan. Tr. koord. soveshch. po seysm. stroitel'stvu. 1956.

An exemplary program of investigations in the field of engineering seismology in the Armenian SSR for the next 10-15 years is presented.

V. A. Nechayev. Determination of the depth of occurrence of the center of an earthquake from the distribution of the force of shock on the locality. DAN Tadzhik SSR(Reports, Acad. Sci. Tadzhik SSR), No. 16, 1956.

A dependence is established between th e depth of the center, force in the epicenter, and force in any other point at a given distance from the epicenter. The resulting formula is suggested for determining the depth of the center of the earthquake.

On the basis of a comparison with the formulas by B. Gutenberg and S. V. Medvedev for determining the depth of centers, the conclusions is made that these formulas are specific cases of the derived general function.

S. V. Puchkov. The limiting force of earthquakes on main rock formations. Izv. AN SSSR, ser. geofiz., No. 7, 1956.

It is shown in the work th at the limiting force of a destructive earthquake on main rock formations does not exceed 7-8 points. An increase up to 9-12 points takes place at the expense of friable, sandy-clayey deposits. The volume of the center of the earthquake is determined.

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S. V. Puchkov and A. Z. Kats. Experience in instrument seismic microdistricting of soils. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

The paper presents a method for calculating the variations of points during passage from one soil to another. The application of this method in the solution of the problem of microdistricting is described.

Ye. F. Savarenskiy. Remarks on the significance of ground conditions for seismic and slope-measuring observations. Tr. Geofiz. in-ta AN SSSR, No. 22(149), 1954.

The paper examines the problem of the influence of shock and slopes, caused by local effects, on the work of seismic and slope-measuring stations in different ground conditions.

A. N. Safaryan. The problem of the seismism of main rock formations and friable quaternary deposits. Yerevan. Tr. koord. soveshch. po seysm. stroitel'stvu, 1956.

The work conducted by the Building Institute in 1952, 1953, and 1954 is summarized. An investigation was made of 10 villages in the area of the city of Gori and 8 villages situated on the Akhalkalaksk Upland.

V. G. Tishchenko. Problems of seismic resistant construction. Vestn. AN SSSR, No. 2, 1955.

A review is made of investigations in the field of seismic resistant construction in the USSR.

A program is outlined for further investigations of problems of the theory and practice of seismic resistant construction.

V. G. Tishchenko and D. A. Khaarin. Vibrations of hydrotechnical structures. Yerevan. Tr. koord. soveshch . po seysm. stroitel'stvu, 1956.

A procedure is given and the results of investigations of vibrations of spillway dams of three hydraulic installations for different forces and conditions of excitation of the vibrations during overflow.

D. A. Kharin and M. S. Fomichev. Vibration of hydrotechnical structions and pulsation of hydrodynamic pressure. Tr. Geofiz. in-ta AN SSSR, No. 16(143), 1952.

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The paper gives the results of investigations of the vibrations of the gate of one of the locks of the Moscow Canal and also of the measurements, during the process of normal sluicing, of the pressure pulsations on the gate and their comparison with the vibrations.

M. G. Khachiyan. Multi-pendulum precision seismometer. DAN Arm. SSSR, vol. 21, No. 5, 1955.

A description is given of a multi-pendulum seismometer intended for seismic microdistricting from the results of weak earthquakes.

STRUCTURE OF THE EARTH ON THE BASIS OF SEISMIC DATA

V. I. Bune and Ye. M. Butovskaya. Year-graph and the structure of the earth's crust in Central Asia from records of powerful explosions. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

The work gives preliminary results of the study of the velocities of ~~xxxxxxx~~ propagation of elastic waves and the structure of the earth's crust in Central Asia on the basis of the year-graph plotted from data of the records of powerful explosions.

The velocities obtained as a result of an analysis of the year-graph differ little from the velocities obtained earlier by Ye. A. Rozova.

G. A. Gamburtsev. Deep seismic sounding of the earth's crust. DAN SSSR, vol. LXXXVII, No. 6, 1952.

Results of observations made in 1949-1950 by the method of deep seismic sounding(DSS) are examined. The results of the completed investigations make it possible to conclude th at the method of DSS is sufficiently developed to be used for the study of deep layers of the earth's crust. The method of DSS makes it possible to study the structure of the medium at those depths at which the centers of earthquakes occur. In connection with this, the DSS should acquire greater importance for the development of the theory of the origin of earthquakes and also in the solution of problems of seismic districting.

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As regards other fields of the application of DSS, the possibility of plotting experimental year-graphs of seismic waves for determining the coordinates of the centers of local earthquakes is pointed out.

G. A. Gamburtsev. Deep seismic sounding of the earth's crust. Tr. Geofiz. in-ta AN SSSR, No. 25(152), 1954.

The main results of experiments for the development of a method of deep seismic sounding of the earth's crust(DSS) are presented. Particularly detailed descriptions are given of the work in the district of North Tyan-Shan, in the process of which the basic features of the x method were developed.

It is pointed out that the method of DSS can be of great significance for a detailed study of the structure of the earth's crust at those depths where the centers of earthquakes occur, in connection with the development of methods for forecasting earthquakes.

G. A. Gamburtsev, P. S. Veytsman, and Yu. V. Tulina. The structure of the earth's crust in the district of ~~xxxx~~ North Tyan-Shan from data of deep seismic sounding. DAN AN SSSR, vol. 105, No. 1, 1955.

In 1949, 1950, and 1953, work was carried on in DSS in North Tyan-Shan in order to study the basic features of the deep structure of the earth's crust. The paper cites the results of a quantitative interpretation of data obtained in one of the districts under investigation over a period of three years.

G. A. Gamburtsev and P. S. Veytsman. A comparison of data of deep seismic sounding of the structure of the earth's crust in the district of North Tyan-Shan with data of seismology and gravimetry. Izv. AN SSSR, ser. geofiz., No. 9, 1956.

A comparison is given of the results of deep seismic sounding(DSS) of the structure of the crust in the district of North Tyan-Shan with data of seismology as regards the distribution of the centers of earthquakes and the nature of the gravitation field. It is shown that, for certain assumptions regarding the relationship between the gravitation field and the

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structure of the earth's crust, it is possible to separate that portion of the gravitation anomalies which is governed by the masses which compose the earth's crust and the upper portion of the sub-crust layer. An example is given of the complex interpretation of the results of DSS and gravimetry.

S. D. Kogan. The existence of deep focal surface on the boundary of the Pacific Ocean. DAN SSSR, vol. 101, No. 1, 1955.

An examination is made of the existence of a focal surface in the north- western Pacific seismic sone, identifiable by a super-deep break.

On the basis of an examination of deep cross sections on the hypocenters of earthquakes during 1909-1944 are shown, th e justification for drawing this break from available seismic data is negated.

I. Ya. Melik-Gaykazyan. Certain characteristics of the structure of the earth's core on the basis of an interpretation of seismic observations. Tr. Geofiz. in-ta AN SSSR, No. 22(149), 1954.

The work deals with the study of the distribution of the velocity of longitudinal seismic waves within the earth's core. In the course of the investigation, the year-graph of the longitudinal waves is reduced to the surface of the core; also, use is made of a procedure which is based on the differential method: the derivative of the year-graph is determined directly from observations.

In order to determine the velocity as a function of the depth, use is made of the Vikhert method. For greater reliability, a control determination is made, based on agreement of the run times, starting with a part-linear function of the velocity with respect to depth and a comparison of the resulting data with observed run times.

As a result of the study of seismograms, th e entry of waves reflected from the boundary of the inner core(sub-core) is detected; a year-graph of these waves was plotted. The latter made it possible to determine sufficiently reliably the radius of the sub-core and the distribution of the velocities therein. Moreover, it was possible to establish

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that the boundary of the sub-core is preceded by a layer 120 km thick in which the velocity decreases with the depth.

I. Ya. Melik-Gaykazyan. The structure of the earth's core. Tr. Geofiz. in-ta AN SSSR, No. 26(153), 1955.

From the observed data, waves reflected from the inner core of the earth are separated. A year-graph of these waves is plotted and conclusions are made about the distribution of velocities within the core and the possibility of the existence of a layer with a reduced velocity of waves situated on the boundary of the core.

T. V. Motorina, S. F. Oborina, and Ye. F. Savarenskiy. Determination of the velocity of propagation of longitudinal waves in the crust of the earth on the basis of observations on a deep earthquake. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

The paper examines the problem of the distribution of the velocities of propagation of longitudinal waves in the crust of the earth during an earthquake with a deep center. From the records of a deep Afghan earthquake on 6 January 1951, calculation is made of the velocity of propagation of longitudinal waves for depth of 100 to 1000 km.

Ye. F. Savarenskiy. The structure of the earth's crust from seismic data. Tr. Geofiz. in-ta AN SSSR, No. 26(153), 1955.

Results are presented of a review of conclusions about the structure of the earth's crust. The ideas about boundaries of a second order are proved to be untenable. The possibility of the existence of intermediate layers is examined.

A. A. Treskov. Seismic investigations of the earth's crust. Tr. Geofiz. in-ta AN SSSR, No. 26(153), 1955.

A review is given of data on the structure of the earth's crust. The advantages and shortcomings of the teleseismic methods proposed by the author for determining the thickness of the earth's crust are discussed and the prospects of further work in this direction are projected.

THEORETICAL AND EXPERIMENTAL STUDY OF SEISMIC WAVES

A. S. Alekseyev and N. V. Tsepelev. Intensity of

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reflected waves in bedded-heterogeneous elastic medium. Izv. AN SSSR, ser. geofiz., No. 9, 1956.

On the basis of energy considerations, a generalization is made of the known, in the case of a multi-layer elastic medium with plane-parallel boundaries of division, formulas for the intensity and forms of recording the reflected waves in the case of heterogeneous layers with curvilinear boundaries of division. The common multiple in the formulas, which determines the geometric divergence of the waves, is calculated for the case of sufficiently thick parallel layers with a vertical gradient of elastic characteristics. One example is given of the calculation of the intensity of the reflected waves in such a medium.

I. S. Berzon. Determination of the exponent of the power of the function of divergence for refracted waves from experimental data. Izv. AN SSSR, ser. geofiz., No. 4, 1951.

A method is proposed for determining the exponent of the power n of the function of divergence for refracted waves from the curves of the amplitude as a function of the distance as obtained from observations of refracted waves by the correlation method. An investigation was made of the applicability of this method for cases in which the exponent of the power n and the absorption coefficient α in the refracting layers are variable magnitudes.

It is shown that the accuracy of determination of the absorption coefficient in the refracting layer depends substantially on the accuracy of determination of the exponent of the power n of the function of divergence. Examples are given of the determination of the exponent n from experimental data.

I. S. Berzon. Variation of predominant frequencies of seismic waves with increasing distance from the source of the vibrations. Izv. AN SSSR, ser. geofiz., No. 1, 1956.

A discussion is presented of the problem of the nature of variation of predominant frequencies of seismic waves

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as a function of the distance from the source of vibration at the expense of the absorbing characteristics of the real media. It is shown that it is possible to have a step-wise variation with the distance of the predominant frequencies of straight, reflected, and refracted waves which propagate in the absorbing media. A discussion is presented of the influence of the spectrum of the explosion, condition of installation of the seismographs, and selection of the characteristics of the seismo-detecting apparatus on the magnitudes of the predominant frequencies of the waves and their variation with distance.

I. S. Berzon. Effective velocities and depths determined from the year-graphs of repeatedly reflected waves. Izv. AN SSSR, ser. geofiz., No. 8, 1956.

For media characterized by a continuous variation of the true velocity with the depth, an examination is made of the effective velocities v_e and the effective depths H_e, as determined from the year-graphs of repeatedly reflected waves, depending on the run time t_0. In the examination, it is assumed that in the process of interpretation the repeatedly reflected waves are accepted as once-reflected waves. It is shown under what conditions the functions $v_e=v_e(t_0)$ and $H_e=H(t_0)$ can be utilized for the recognition of repeated waves.

Yu. I. Vasil'yev. Determination of the coefficient of absorption of seismic waves. Izv. AN SSSR, ser. geofiz., No. 4, 1951.

Methods are proposed for determining the amplitude coefficient of absorption for straight and refracted waves. These methods can be applied for processing observed amplitude graphs obtained in work with the correlation method of refracted waves.

The absorption coefficient is a physical parameter which characterizes the medium in which the elastic wave propagates. The utilization in seismic surveying of data on the absorption coefficients along with data on the velocities of

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their propagation makes it possible to study more completely the structure of different media.

Ye. I. Gal'perin. The solution of straight space problems of geometric seismics for multi-layer media with division boundaries of random form. Izv. AN SSSR, ser. geofiz., No. 4, 1956.

A graphical method is described for the solution of straight space problems of geometric seismics for multi-layer media with division boundaries of random form. The method is based on the application of stereographic projection(Wolf network). The methodsof construction are analyzed with examples of the solution of problems for reflected and refracted waves.

B. M. Gol'tsman. Problem of spectral analysis of seismic waves. Vestn. Leningr. un-ta(Herald of Leningrad Univ.), No. 2, 1954.

The basic goal of the work is the investigation of the signal at the exit of a narrow-band resonant system in order to establish the relationship between this signal and the "mathematical" spectrum of the original impulse and to examine further concrete means of the investigation of spectra in different cases.

The theoretically derived conclusions are confirmed experimentally by means of a spectroanalyzer which is briefly described.

O. D. Gotsadze. Determination of the position of refracting and diffracting surfaces of the earth's crust from the angular anomalies of a seismic ray. Izv. AN SSSR, ser. geofiz., No. 9, 1956.

The work examines several problems of the determination of the structure of the medium from the angular anomalies at one station. The presentation is made specifically to problems of seismology when the direction of the ray is determined from the amplitudes of the entries of the longitudinal waves; however, the proposed methods are applicable also to problems of surveying when the direction of the rays is determined from the surface space year-graphs.

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G. I. Gurevich. The relationship of elastic residual deformations in a general case of uniform stressed condition. Tr. Geofiz. in-ta AN SSSR, No. 21(148), 1953.

The classic model of an elastic body as a system of material points connected by the action of central forces is supplementdd by taking into account the regroupings of these "points" which leads to a relaxation of stresses and residual deformation. A system of equations is derived which characterizes this process; it combines the main stresses and deformations(both elastic as well as residual) of the elementary parallelopiped of a uniform, isotropic body. On the basis of the developed conceptions, an attempt is made to establish that "limiting relationship" between the stressed condition, temperature, and velocity of deformation of solid bodies to which the changeover to the stage of accelerated residual deformation(and as a result,--impact destruction) is approximately assigned.

G. I. Gurevich. Problem of physical foundations of the theory of propagation of elastic waves. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

On the basis of previously developed general concepts of the mechanical properties of materials, a three-dimensional system of equations of the propagation of elastic waves in a homogeneous medium is derived; the medium can be ideally elastic, liquid, or in any other of the intermediate conditions. The equations are suitable for cases of small stresses(for example, for the case dealing with seismic vibrations not from strong earthquakes and not in immediate nearness from the center). In the most general aspects, an examination was also made of the regularities of damping of vibrations under great stresses. Indication is made of the relationship and difference between the mechanical properties of materials under conditions of laboratory investigation(static tests) and under conditions of the propagation of seismic vibrations.

G. I. Gurevich. Problem of the nature of slow movements

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connected with earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 31 (158), 1955.

The paper presents certain arguments that high-frequency vibrations of the soil, which occur during an earthquake, should, as a rule, always be preceded by "slow movements" which, of course, require the proper technical possibilities for their detection.

A. M. Yepinat'yeva. Certain types of repeated seismic waves. Izv. AN SSSR, ser. geofiz., No. 1, 1956.

Theoretical and experimental investigations are cited of the kinematic and dynamic characteristics of repeated reflected and reflected-refracted waves, the first reflection of which occurs from the division boundary situated above the source of excitation of the vibrations. Experimental data agree with the theoretical.

L. P. Zaytsev and N. V. Zvolinskiy. Investigation of the head wave which occurs on the division boundary of two elastic liquids. Izv. AN SSSR, ser. geofiz., No. 1, 1951.

Dynamic characteristics are presented of the head wave which forms during the fall of a wave with a non-planar front on the division boundary of two elastic media. The characteristics of this wave are of interest in the interpretation of seismic observations. The investigation of the head wave was conducted by the method of functional-invariant solutions proposed by V. I. Smirnov and S. L. Sobolev on the hypothesis of plane-polarized vibrations and plane division boundary of the media. The source of the vibrations is taken as point-like, of the expanding center type.

L. P. Zaytsev and N. V. Zvolinskiy. Investigation of the axially symmetric head wave which occurs on the plane division boundary of two elastic liquids. Izv. AN SSSR, ser. geofiz., No. 5, 1951.

A study was made of the ~~axially symmetric~~ dynamic characteristics of an axially symmetric head wave which during

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the fall of a wave with a non-planar front, excited by a point source of the expanding center type on a plane division boundary of two elastic liquids.

The results obtained for plane-polarized ~~surfaces~~ vibrations are utilized in the solution.

K. K. Zapol'skiy. Dynamic year-graphs of seismic waves. Izv. AN SSSR, ser. geofiz., No. 3, 1955.

A method is described for plotting dynamic year-graphs which represent the combination of kinematic year-graphs and amplitude curves. Illustrations are shown of the application of dynamic year-graphs in the correlation of waves and the study of the characteristics of their propagation. As examples, use is made of dynamic year-graphs of head and surface waves, which were plotted in connection with the study of small depths by means of impacts.

N. V. Zvolinskiy. Repeated reflections of elastic waves in a layer. Tr. Geofiz. in-ta AN SSSR, No. 22(149), 1954.

An examination is made of a plane problem of repeatedly reflected waves in an elastic ~~medium~~ layer lying on an elastic semispace. The concept of local coefficients of reflection, which characterize the intensity of the reflected waves in the pre-frontal zone, is introduced.

For certain typical values of the velocities of propagation, the local coefficients of reflection along the front have been calculated and the results are presented in the form of graphs. The calculations are, in the main, reduced to three-fold reflections inclusively.

The results in this paper are of great significance also for the solution of the axially symmetric problem.

N. V. Zvolinskiy and G. A. Skuridin. Asymptotic method of solving dynamic problems of the theory of elasticity. Izv. AN SSSR, ser. geofiz., No. 2, 1956.

An examination is made of the application of the asymptotic(for high frequencies) method for solving dynamic problems of the theory of elasticity and a solution is given of the problem of the reflection of a cylindrical elastic wave from the boundary(rigid or free) of semispace. The problem is

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formulated as a Koshi problem for a definite front (eikonal) of the wave and its amplitude.

P. K. Ishkov. Propagation of elastic waves in a layer lying on an elastic base. Izv. AN SSSR, ser. geofiz., No. 2, 1956.

The conditions of existence of a wave moving along the division surface are explained for the case of incompressibility of materials by the Lamb method. The possible velocities of this wave as a function of the elastic constants of materials are determined.

The tables and graphs give an idea of the dispersion of the wave, both on the division surface and on the free boundary of the layer joined along the rectilinear boundary with the elastic base.

Ye. V. Karus and I. P. Pasechnik. Study of elastic and absorbing characteristics of rocks in their natural occurrence by methods of seismic acoustics. Izv. AN SSSR, ser. geofiz., No. 6, 1954.

A brief description is given of the physical bases of a method, apparatus, and technique developed by the author for making observations to determine th e elastic and absorbing characteristics of rocks in their natural occurrence. The method is based on the study of the nature of propagation in rocks of elastic, stationary sinusoidal vibrations with frequencies of 50-100 to 3000-4000 cycles per second, excited by electromagnetic or piezoelectric vibrators with a low input. By means of the given method, it is possible to determine the phase velocities of the propagation of elastic stationary sinusoidal vibrations and the values of the amplitude coefficients of absorption of these vibrations in rocks during observation on the earth's surface and in underexcavations.

V. I. Keylis-Borok. Surface waves in a layer lying on an elastic semispace. Izv. AN SSSR, ser. geofiz., No. 2, 1951.

An examination is made of certain characteristics of surface vibrations caused by a sinusoidally concentrated force on the free boundary of a plane-parallel layer lying on an

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elastic semispace.

Calculation is made of the dispersion and frequency characteristics of the layer corresponding to the averaged earth's crust. An analysis is made of certain experimental data of the surfaces of seismic waves; the nature of so-called Raleigh and pseudo-Raleigh seismic waves.

V. I. Keylis-Borok. Equation of frequencies of a multi-layer elastic medium. DAN SSSR, vol. LXXXVII, No. 1, 1952.

The work examines the equation of frequencies for an n-layer semispace--elastic system consisting of a random number of n plane-parallel layers and a semispace filled with a homogeneous isotropic medium. Displacements and normal stresses--are continuous functions of the coordinates(rigid contact); on the boundary of the system under consideration, the stresses are equal to zero.

V. I.Keylis-Borok. Problem of the frequency characteristics of a layer lying on semispace as a function of the depth of the source. Tr. Geofiz. in-ta AN SSSR, No. 16(143), 1952.

The work examines the sinusoidal surface vibrations of a layer lying on a semispace and rigidly connected with it along the boundary plane. The medium in the lay er and in the semispace is considered as homogeneous, isotropic, and ideally elastic. The source of the vibrations is a concentrated force applied to the boundary between the layer and the semispace and directed perpendicularly to this boundary. Calculations are made of the frequency characteristics for an averaged earth's crust and for a layer of alluvia on granite. The results can be utilized in the study of surface waves and microseisms of deep origin.

V. I. Keylis-Borok. Problem of the propagation of stationary vibrations in a layer lying between two semispaces. Tr. Geofiz. in-ta AN SSSR, No. 20(147), 1953.

An examination is made of sinusoidal vibrations caused by a point source in an ideally elastic medium consisting of a layer lying between two semispaces.

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It is established that the main portion of the displacement at a distance from the source is comprised of waves of a special type. Certain characteristics of these waves have been investigated.

V.I.Keylis-Borok. Problem of resonant characteristics of interference waves in a layer. Tr. Geofiz. in-ta AN SSSR, No. 22(149), 1954.

An examination is made of the resonant characteristics of sinusoidal interference waves of the type of Neimark wave, caused by a center of expansion--compression in a layer lying between two semispaces.

V.I. Keylis-Borok. Propagation of vibrations in a multi-layer semispace. DAN SSSR, vol. XCV, No. 4, 1954.

On the basis of results obtained in the solution of the posed problem, the characteristics of interference waves are established.

I. P. Kosminskaya. Interference of seismic waves caused by a harmonic source. Izv. AN SSSR, ser. geofiz., No. 4, 1952.

An investigation was made of the form of a year-graph of the phases and amplitude curve of an interference seismic vibration registered in the case of a harmonic source as a function of th e basic parameters(velocities and amplitudes of the components ~~of the~~ waves). Signs are identified from which it is possible to establish the existence of interference phenomena on the observed curves.

A graphical method is proposed for plotting year-graphs of the phases and amplitudes of curves of a complex harmonic vibration for any number of component waves and random laws of the variation of their amplitudes and velocity.

I. P. Kosminskaya. Amplitude curves and year-graphs of thephases of seismic waves caused by a source of point expansion in a homogeneous, ideally-elastic, ~~infinite~~ limitless space. Izv. AN SSSR, ser. geofiz., No. 6, 1952.

Amplitude curves are shown and year-graphs of the ph ases of waves of displacements caused by a point(harmonic and impulse) source of the type of expansion center in a homo-

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geneous, ideally elastic space. The main regularities noted for year-graphs of the phases and the amplitude curves of waves caused by a harmonic source are, in the main, valid for waves caused by an impulse source which excites quasi-sinusoidal vibrations.

I. P. Kosminskaya. Amplitude curves and y ear-graph s of the phases of waves caused by a harmonically concentrated force in a h omogeneous, ideally elastic space. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

An analysis is given of the form of amplitude curves and year-graphs of the phases of a complex vibration occurring in a homogeneous, ideally elastic space in the caseof action of a harmonically concentrated force. Graphs are shown of the corresponding curves for longitudinal and transverse profiles.

I. P. Kosminskaya. Methods of analysis of amplitude curves and year-graphs of the phases of complex harmonic waves. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

Methods are described for determining the amplitude curves and year-graphs of the phases of the simple seismic waves from the corresponding graphs of complex harmonic vibrations. The method of envelopes was used to determine the amplitudes of simple waves. The year-graphs of simple waves are determined by three methods: from a transparent sheet of th e year graphs, from the points of intersection of the amplitude curves of a complex and dominating waves, and from the magnitude of the interval between the like extremes of the amplitude curve of the complex wave.

I. P. Kosminskaya. Amplitude curves and year-graphs of the phases of seismic waves on a free boundary of semispace. Izv. AN SSSR, ser. geofiz., No. 1, 1956.

Year-graphs of phases are shown and amplitude curves of waves caused by a concentrated harmonic force during excitation and registration on a free boundary of a homogen eous, isotropic semispace. In the case of an ideally elastic medium, the dominating wave at a distance of $r \geq \lambda_p$ (λ_p is th e length of the longitudinal wave) is the Raleigh wave. In the case of the absorbing medium, if one is to follow th e theory of damping by B. V. Deryagin, then the Raleigh waves of longitudinal waves

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are the dominating waves in different points of the free surface. The transverse waves in the case of a free surface are not dominating.

G. S. Markhasev. Head waves in elastic media with a plane boundary. Prikl. matematika i mekhanika (Applied Mathematics and Mechanics), vol. XIX, No. 2, 1955.

An examination is made of two infinite elastic media $z>0$ and $z<0$ which are in contact along the plane $z=0$. At a distance x z* from the boundary in the first (upper) medium, a point source is in action.

The problem of the propagation of elastic vibrations is solved by the method of functional invariant solutions of V. M. Smirnov and S. M. Sobolev.

F. I. Monakhov. Problem of the direction of vibration of the soil during an earthquake. Tr. Geofiz. in-ta AN SSSR, No. 16(143), 1952.

The paper presents data of observations regarding the direction of horizontal vibrations of the soil during weak earthquakes and an analysis of the results is given. The investigations were conducted on the basis of instrument data.

The observations have shown that during weak earthquakes at distancesof several tens of kilometers from the epicenter, the movement of particlesof the soil in a horizontal plane can take place along one straight line, along two main straight lines, and along rather complex curves. The direction of the vibration of the soil depends on the structure of the upper portions of the earth's crust and on the direction of the forces in the center.

F. I. Monakhov. Angles of exit of longitudinal seismic waves in the district of South Sakhalinsk. Tr. Geofiz. in-ta AN SSSR, No. 36(163), 1956.

The paper contains the results of experimental observations of the angles of exit of longitudinal seismic waves in the district of South Sakhalinsk from data of the South Sakhalinsk seismic station.

T. I. Oblogina. Dynamic characteristics of diffracted elastic waves. Izv. AN SSSR, ser. geofiz., No. 4, 1956

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The characteristics of seismic waves in the case of dynamic diffraction are examined from the point of view. On the basis of a solution of a plane and a three-dimensional problems of the diffraction of elastic waves from the edge of rigidly fixed rectilinear cross section, determinations were made of the dynamic year-graphs and theoretical seismograms of the diffracted waves. It is shown how the nature of entry, amplitude, and predominant period of the impulse wave vary as a result of diffraction.

A. Ye. Ostrovskiy. Long-period vibrations during earthquakes Byull. Soveta po seysmologii, No. 1, 1955.

Certain methodical characteristics of the registration of long-period vibrations are presented and the apparatus used for this purpose is described. Various earthquakes were recorded in Garm and Ashkhabad by means of seismic slope meters. Individual seismograms indicate the possibility of the existence of long-period vibrations which precede and accompany the main vibrations. However, individual records do not yet permit to make positive conclusions and, for this reason, it is necessary to expand the observations by means of seismic slope meters.

G. I. Petrashen and K. I. Ogurtsov. Dynamic problems of the theory of elasticity, part 1. Uch. zap. Leningr. gos. un-ta(LGU), ser. matem.(Sci. Memoirs, Leningrad State Univ., Mathemat. Series), No. 149, issue 24, 1951.

This number of scientific memoirs is the first of a series of numbers dealing with the dynamic problems of the theory of elasticity, which were solved during recent years in the Leningrad State University. All the papers in these numbers fall within the community of methods for the solution of problems and also methods of investigating solutions, undertaken with the purpose of obtaining physical results. The basis of all the investigations is the method of the incomplete separation of variables, which was originated and developed by the Leningrad State University. The method referred to made it

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possible to simplify substantially the solution of many problems previously examined by other authors and also made it possible to make an investigation of the solutions of various other problems which previously could not be solved in a satisfactory manner.

G. I. Petrashen. Propagation of elastic waves in lamellar-isotropic media divided by parallel planes(Dynamic problems of the theory of elasticity, part II). Uch. zap. LGU, ser. matem., No. 162, issue 26, 1952.

The work presents the laws of propagation of waves in lamellar-isotropic elastic systems limited by parallel planes. The problems are formulated in terms of the mathematical theory of elasticity, while their exact solutions are attained by the method of incomplete division of the variables.

Investigations of the solutions are conducted by means of the method of the stationary phase which makes it possible to study the propagating waves in wide regions of the wave field. Morecver, only those waves which follow in their propagation the laws of geometric seismics were subjected to quantitaitve evaluations.

All the problems being examined are only first subjected to an analytical investigation. The methods developed in the work can be successfully applied also in other fields of mathematical and theoretical physics.

G. I. Petrashen, N. S. Smirnova, G. I. Makarov, and B. Ya. Gel'chinskiy. Propagation of waves in media containing spherical or cylindrical division boundaries(Dynamic problems of the theory of elasticity, part III). Uch. zap. LGU, ser. matem., No. 170, issue 27, 1953.

The present issue of scientific memoirs is the third of numbers dealing with the dynamic problems of the theory of elasticity as solved in the LGU.

The published papers present effective methods of the study of the laws of propagation of waves in media containing spherical and cylindrical division boundaries; the application of these methods is far from being exhausted by the field of the

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dynamic theory of elasticity. The results of the works dealing with the very important and slightly studied division of non-stationary problems of mathematical physics h ave great scientific significance.

G. I. Petrashen and V. A. Yepal'skiy. Certain interference phenomena in media containing plane-parallel layers. Izv. AN SSSR, ser. geofiz., No. 9, 1956.

An examination is made of problems of the propagation of transverse waves of the type SH in two- and three- layer media with plane-parallel division boundaries and containing an a thin layer. Exact formulas are obtained for wave fields and the directions of investigations with the purpose of obtaining physical results are discussed.

Yu. V. Riznichenko. Determination of elements of occurrence of refracting boundary on the assumption that it is plane only in the field of reception of seismic waves. Izv. AN SSSR, ser. geofiz., No. 3, 1951.

A discussion is presented of the possibility of a quantitative interpretation of the observations of refracted seismic waves when the structure of the medium on the path from the sources of the vibrations to the field of reception is distinguished by great complexity. No assumptions are made regarding the structure of the medium on this path. It is only admitted that, in the field of reception, the refracting boundary is plane and the boundary velocity and velocity in the covering medium are constant. Under these conditions, determination is made of the angle and direction of fall of the boundary in this region.

A general discussion is given of the different variants of the problem and a complete solution is given for the case when the number of observations is equal to two.

Yu. V. Riznichenko. Joint processing of various observations of head seismic waves. Izv. AN SSSR, ser. geofiz., No. 1, 1952.

An examination is made of direct and reverse problems of

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geometric seismics of the head refracted waves caused by one or several sources in order to determine the seismic velocities and elements of occurrence of the refracting platform; moreover, no assumptions are introduced regarding the structure of the medium outside the field of reception of the vibrations.

The proposed methods of interpretation of the seimsic observations can find application in the solution of certain surveying problems and also in deep sounding of the earth's crust by means of distant explosions and in processing data obtained by the correlation methods of registering waves from "close" natural earthquakes.

Yu. V. Riznichenko. Miniaturization of seismic phenomena. Vestn. AN SSSR, No. 5, 1952.

The goals of miniaturization of seismic phenomena are reported. A brief characterization is given of work in miniaturization of seismic waves, as carried out in the Geophysical Institute of the Academy of Sciences USSR.

Yu. V. Riznichenko. Determination of the fields of intensity of seismic waves. Izv. AN SSSR, ser. geofiz., No.1, 1954.

In the region near the front of the wave, the energy of the vibrations propagates along the rays. Its course is analogous to an irrotational course of an incompressible liquid. In connection with this analogy, the problem of the determination of the intensity of seismic waves within the medium is formulated, if the year-graphs and intensities of the vibrations(or amplitudes of displacements) on the surface are given. A method of solving this problem is proposed.

Yu. V. Riznichenko, B. N. Ivakin, and V. R. Bugrov. Miniaturization of seismic waves. Izv. AN SSSR, ser. geofiz., No. 5, 1951.

An examination is made of the possibility of different methods of study of wave phenomena under laboratory conditions for the miniaturization of seismic waves applicable to problems of seismic surveying and the study of earthquakes. Descriptions are given of experimental investigations for the

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development of a method based on the utilization of elastic vibations primarily of ultrasonic frequency.

The developed method makes it possible to obtain in the laboratory seismograms similar to those which are obtained in the field during seismic surveying by the method of refracted waves and which can be obtained by means of multi-canal recording of the waves of earthquakes.

Yu. V. Riznichenko, B. N. Ivakin, and V. R. Bugrov. Miniaturization of seismic waves by means of ultrasonic impulses. Izv. AN SSSR, ser. geofiz., No. 3, 1952.

A description is given of an ultrasonic installation for the miniaturization of seismic waves,applicable to problems of seismic surveying and the study of earthquakes. Examples are given of work with this installation: miniaturization of the two-dimensional Lamb problem of the propagation of waves in a solid elastic semispace; miniaturization of the three-dimensional problem of the propagation of head refracted waves connected by thin layers; determination of the elastic characteristics of solid and loose rocks(in particular, measurement of the velocities of propagation of longitudinal w waves in these rocks) on specimens of small dimensions and random shape.

Yu. V. Riznichenko, B. N. Ivakin, and V. R. Bugrov. Impulse ultrasonic seismoscope. Izv. AN SSSR, ser. geofiz., No. 1, 1953.

An instrument is described for the miniaturization of seismic waves observed in seismic surveying and in the study of earthquakes.

Ye. F. Savarenskiy. Angles of exit of seismic radiation and certain related problems. Tr. Geofiz. in-ta AN SSSR, No. 15(142), 1952.

This present work deals with the methods of direct measurement of the angle of exit of seismic radiation. An investigation is made of the method of determining the angle of exit from observed displacements in the vertical and horizontal components. The method was first used by Golitsyn, but during the past time, the solution of the problem was not

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advanced by any one. Much has been done anew. An evaluation is given of the maladjustment of the instruments on the measured angle of exit. An investigation is made of the influence of the layers of the earth's crust. Practical instructions are developed for measuring the angle of exit. A differential method is proposed for measuring the angle of exit, based on the study of the difference in times of approach of the waves to two seismic stations close to each other.

G. A. Skuridin. Approximate solution of the problem of diffraction of a plane elastic wave relative to a slit. Izv. AN SSSR, ser. geofiz., No. 1, 1955.

An approximate solution is given of the problem of diffraction of a plane longitudinal wave relative to a slit by means of the principle of Huygens-Kirchoff for the equations of elasticity. The resulting formulas make it possible to give a quantitative analysis of the diffraction field. The calculations are illustrated with numerous graphs.

G. A. Skuridin. Jumps in discontinuous solutions of dynamic equations of the theory of elasticity. Izv. AN SSSR, ser. geofiz., No. 6, 1956.

A justification is given for the asymptotic method of solving dynamic problems of the theory of elasticity by means of an examination of discontinuous solutions of the equations of elasticity. It is shown that, on the front of the wave, the differential equations for the jumps of the discontinuities of the field of displacements of the longitudinal and transverse waves coincide with the differential equations for the amplitudes of the corresponding approximate solutions. The resulting differential equations for the jumps of the discontinuity make it possible to pass to a solution of the marginal dynamic problems in the case of homogeneous as well heterogeneous medium.

N. V. Tsareva. Propggation of elastic waves in sand. Izv. AN SSSR, ser. geofiz., No. 9, 1956.

A method is presented and the results of an investigation of the propagation of elastic waves in sand and the velocity of

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propagation as a function of the pressure, direction of propagation of the waves with respect to the direction of the applied pressure, and grain size of the sand.

O. G. Shamina. Frequency analysis of seismic vibrations. Izv. AN SSSR, ser. geofiz., No. 8, 1956.

A description is given of the apparatus and the procedure developed for the frequency analysis of seismic vibrations by means of a harmonic analyzer. The apparatus and procedure are intended for the analysis of vibrations occurring during the destruction of rocks and can be utilized also for the analysis of vibrations registered in the study of the structure of the earth's crust by seismic methods. First, an examination is madeof the requirements of the accuracy of analysis of the impulses and of the analyzing apparatus. Examples are given of the frequency analysis of impulses in the form of sections of a sinusoid, damping sinusoid, and short imuplse.

SEISMIC APPARATUS

L. I. Bokanenko. Determination of frequency and phase characteristics of electrodynamic seismic receivers by means of additional exciting coils. Izv. AN SSSR, ser. geofiz., No. 7, 1956.

The justification and description are given of a method for determining the frequency and phase characteristics of electrodynamic seismic receivers; the method is based on the utilization in the seismic receiver of an additional exciting coil mechanically and rigidly connected with the movable system of the instrument. It is shown that, during the excitation of the seismic receiver by means of an additional coil, the determinable frequency and phase characteristics of the seismic receiver do not practically depend on the conditions of its installation.

B. F. Bonchkovskiy and S. Namsaray. Accuracy of readings of slope meters. Tr. Geofiz. in-ta AN SSSR, No. 22(149), 1954.

On the basis of an analysis of the readings of several parallel established slope meters, the paper makes the conclusion that

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conclusion that the slope meter is a rather accurate instrument which makes it possible to measure slopes with an accuracy of up to 0.1" of an arc. At the same time, this confirms the fact of possible difference in the slopes at two adjacent points of measurement.

Ye. S. Borisevich. Registering instruments for seismic stations. Tr. Geofiz. in-ta AN SSSR, No. 14(141), 1952.

The paper describes registering instruments installed at the given time at fixed seismic stations and also certain new models produced as experimental types. Kinematic systems are given of instruments and drawings which explain their arrangement and principle of action of the mechanisms.

Ye. S. Borisevich. Gear box for registering instruments. Tr. Geofiz. in-ta AN SSSR, ser. geofiz., No. 20(147), 1953.

Descriptions are given of the principal systems of gear boxes for registering instruments; these were developed by the author. The simplicity of the mechanism and the reliability in operation, as checked during use for several years, makes it possible to recommend it for application in different instruments. At the present time, such a gear box is used in many experimental and mass-produced magneto-electric oscillographs developed in the Geophysical Institute Acad. Sci. USSR.

Ye. S. Borisevich. Oscillograph of a movable seismic station(OMSS). Tr. Geofiz. in-ta AN SSSR, No. 29(156), 1955.

A description is given of a 12-canal magnetoelectric oscillograph developed in the Geophysical Institute in 1950 for an experimental movable seismic station. This oscillograph utilizes for the first time a load drive which assures operation of the belt-drawn mechanism and also a block of galvanometers with a common permanent magnet made of the alloy "magniko." Registration is accomplished on a film at speeds of 2 and 25 mm/sec. Electric feed of the oscillograph is reduced to a minimum and does not require cumbersome storage batteries.

The oscillograph(OMSS), as installed at the experimental

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movable ~~xxxxxx~~ seismic station, was utilized during several field seasons and showed satisfactory operational x results.

Ye. S. Borisevich. Magnetoelectric oscillograph OSB-1. Tr. Geofiz. in-ta AN SSSR, No. 29(156), 1955.

The paper describes a new model of a portable, multi-canal magnetoelectirc oscillograph developed in the Geophysical Institute and intended for prolonged registration of slow processes.

The oscillograph is equipped with low-frequency galvanometers of high sensitivity with electromagnetic damping. Registration is accomplished on a small drum covered with photo-paper, which rotates uniformly and is displaced uniformly along the axis by means of a spring drive. The speed of rotation of the drum and the speed of its longitudinal displacement can vary within definite limits.

The oscillograph OSB-1 is quite economical, both from the viewpoint of consumption of photographic paper as well electric current being consumed.

Ye. S. Borisevich. Simplified oscillograph UO-9. Tr. Geofiz. in-ta AN SSSR, No. 29(156), 1955.

The paper describes the portable, nine-canal simplified oscillograph UO-9 for geophysical investigations.

Registration is accomplished on photographic paper 12 cm wide at a speed of 0.25 to 4 mm/sec. Rewinding of the photo-paper is accomplished not by an electric motor but by a spring drive with a movement regulator which frees the circuit of the oscillograph from electrical disturbances. Feeding of the instrument during field investigations does not require cumbersome batteries because the input does not exceed 5 watts. The oscillograph can function continuously for over 5 hours.

Ye. S. Borisevich. New mirror galvanometers for magneto-electric oscillographs. Tr. Geofiz. in-ta AN SSSR, No. 29(156), 1955.

The paper describes a new design of mirror galvanometers of the GB type developed by the author in th e Geophysical Institute Acad. Sci. USSR and used in new models of magneto-electric oscillographs which are being produced experimentally and commercially.

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and on a large scale.

The characteristics are given of the different variants of the type GB galvanometers, which were checked under operating conditions. A description is also given of a magnetic system with a permanent magnet made of "magniko" alloy in which these galvanometers are mounted.

L. S. Veytsman. Selection of distances between seismogrpahs during groupings in order to reduce the background of disturbances. Izv. AN SSSR, ser. geofiz., No. 6, 1952.

The problem is examined of the selection of distances between the seismographs during grouping in order to increase the effective sensitivity of the apparatus in the presence of microseisms of wind origin. A description is given and also the results of experiments on the selection of working distances between the seismographs in the group and also an evaluation of the effect of grouping. It is recommended that the distances be selected from the indication of the loss of phase correlation on the records of the microseisms by the individual instruments of the group. The experiments were conducted in Tyan-Shan by a seismic station which operated on the principle of deep sounding.

Ye. V. Ventskevich, I.P.Pasechnik, and N. Ye. Fedoseyenko. Application of a lagging development in the registration of seismic vibrations. Izv. AN SSSR, ser. geofiz., No. 5, 1956.

A description is given of a method and apparatus for multi-photo-canal registration of seismic vibrations, the time of arrival of which is unknown beforehand; moreover, the speed of the development can be reduced to 50 mm/sec. The method is based on the application in the registers of a lagging development which is automatically included at the moment of arrival of the first impulse of the vibrations in the seismograph.

G. A. Gamburtsev. High frequency seismometry. DAN SSSR, vol. XXXVIII, No. 5, 1953.

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An examination is made of the problem of the application of high-frequency narrow-band filtration in seismology.

The significance of the development of methods of high-frequency seismometry is pointed out.

G. A. Gamburtsev. Two systems of operation of horizontal pendulums. Izv. AN SSSR, ser. geofiz., No. 3, 1953.

It is shown that, for a gravitation-astatic torsion pendulum, two systems of operation exist, which differ considerably with respect to the magnitude of the attainable maximum period and, consequently, the sensitivity to slopes. In order to make possible operation in a more advanatageous system, it is necessary for the position of equilibrium of the system with the simultaneous action of the gravitation and elastic forces to be the same as during the action of only two elastic forces, i. e., it is necessary for the supporting thread to be in a torsion-free condition. Twisting of the system for small fractions of a degree leads already to a sharp drop in the sensitivity.

G. A. Gamburtsev. New methods and apparatus for the registration of seismic phenomena. Tr. Geofiz. in-ta AN SSSR, No. 25(152), 1954.

It is pointed that it is possible and expedient to register natural seismic phenomena in searching for forerunners of earthquakes at considerably higher and lower frequencies than is customary in seismology. It is pointed out that it is expedient to utilize in the study of regional seismism the correlation principles of the registration of seismic waves as developed in seismic surveying.

G. A. Gamburtsev. Optical seismic slope meters. Izv. AN SSSR, ser. geofiz., No. 4, 1954.

The theory is presented of new-type instruments--optical seismic slope meters intended for recording slow vibrations of the earth's crust in the given range of frequencies, in particular for the registration of long-period seismic waves;

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the possibility of obtaining a very high sensitivity by means of "double" seismic slope meters is pointed out.

G. A. Gamburtsev and Ye. N. Gal'perin. Procedure of the correlation method for the study of earthquakes. Izv. AN SSSR, ser. geofiz., No. 1, 1954.

A description is given of two modifications of the correlation method for the study of earthquakes(CMSE) as applicable to the problem of the investigation of the territorial distribution of the centers of local, very weak high-frequency seismic jolts.

The problems of the apparatus, procedure of field observations, and interpretation of their results are examined.

G. A. Gamburtsev and Ye. I. Gal'perin. Azimuth seismic observations with sloping seismographs. Izv. AN SSSR, ser. geofiz., No. 2, 1954.

A description is given of the procedure of observations of earthquakes by means of an azimuth installation with sloping seismographs. The advanatages of installations of this type in comparison with azimuth installations with horizontal and one vertical seismographs are shown. Examples are shown of the registration and determination of the direction of the vector of displacement of the ground for local earthquakes in the Pamir area in 1953.

K. K. Zapol'skiy, Ye. I. Gal'perin, and Ye. S. Borisevich. Experimental movable low-frequency seismic station. Tr. Geofiz. in-ta AN SSSR, No. 29(156), 1955.

A description is given of an apparatus set developed for the study of the possibility of multi-canal registration of close earthquakes within the frequncy range of 1 to 25 kilocycles.

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D. P. Kirnos. Certain problems of instrument seismology. Tr. Geofiz. in-ta AN SSSR, No. 27(154), 1955.

The present work is a generalization of the results of investigations by the author, connected with the development of various new systems of seismic instruments intended ch iefly for equipping seismic stations.

This work presents the problems of the theory and justification of methods of calculation and design of seismic instruments with direct and galvanometric registation and which are the most perfect for stationary observations. The general presentation of these problems is illustrated with a description of the elements of calculation and design, methods of determination of the constants, and results of tests of three new systems of seismographs developed by the author in connection with the reorganization of the seismic service of the USSR.

I. L. Nersesov. Signal instrument of strong, close earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 21(148), 1953.

The paper describes the system of a contact signal instrument of strong earthquakes.

I. L. Nersesov. The coupling coefficient of seismograph--galvanometer. Tr. Geofiz. in-ta AN SSSR, No. 36(163), 1956.

The paper examines the problem of the influence of the coupling coefficient on the system seismograph--galvanometer. It is shown that the existence of a coupling between the galvanometer and the seismograph requires, during identification of of the instrument constants, to identify also the coupling coefficient of the latter.

I. P. Pasechnik. Procedure of experimental study of resonance phenomena in the oscillating system ground--seismograph. Izv. AN SSSR, ser. geofiz., No. 1, 1952.

A description is given of a developed and in-practice applied procedure for the experimental study of resonance phenomena in a mechanical oscillating system which is formed by the ground and the seismograph installed on its surface. A brief description is given of the apparatus used therein and of the procedure for processing the results of the observations.

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Examples are shown of observed frequency and phase resoance curves and of records of natural vibrations of the system ground--seismograph as obtained in different seismological conditions.

I. P. Pasechnik. Results of an experimental study of resonance phenomena in the vibrating system ground--seismograph. Izv. AN SSSR, ser. geofiz., No. 3, 1952.

Results are presented of an experimental study of the characteristics of the vibrating system ground--seismograph as a function of its parameters: velocity of propagation of longitudinal waves in the ground and density of the ground, weight and area of base of the seismograph. Data are shown of the influence of different methods of installation of seismographs on the resonance characteristics of the system ground--seismograph. The influence of resonance in the system on the nature of seismic methods is shown. For different surface conditions, methods of installation of seismographs are pointed out for which the resonance phenomena are absent or a expressed slightly.

I. P. Pasechnik. Azimuth four-component installation with sloping seismographs. Izv. AN SSSR, ser. geofiz., No.3, 1956.

A description is given of an azimuth four-component installation with sloping seismographs, intended for the registarion of local earthquakes. The installation was employed in the work in the Khaitsk epicenter zone of the Garm oblast. The advantages are shown of records of four-component installations with sloping seismographs in comparison with records obtained at ordinary, three-component installations with two horizontal seismographs and one vertical.

V. N. Solov'yev. Photoelectric signal instrument of strong earthquakes. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

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The paper describes an instrument which is installed at a seismic station and is intended for notifying the staff of the station about an earthquake that is taking place and also for including, for sufficiently large amplitudes, of an additional battery of illuminating lamps and reduce the sensitivity of the seismographs.

M. I. Subbotin and I. L. Nersesov. Fluxometric slope meter. Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

The work contains the theoretical justification and the results of an experimental check of the fluxometric method of measuring short-period slopes of the earth's surface. Investigations of the fluxometric slope meter show that such an instrument is suitable for recording "short" slopes of the earth's surface.

N. Ye. Fedoseyenko. A portable high-frequency station for parameter measurements. Izv. AN SSSR, ser. geofiz., No. 7, 1956.

A description is given of an 8-canal portable high-frequency seismic station for parameter measurement of velocities on small bases, fitted for operation both on the surface of the earth as well as underground.

D. A. Kharin. Quality of vibration measuring instruments with mechanical and optical methods of registration. Tr. Geofiz. in-ta AN SSSR, No. 14(141), 1952.

The paper presents the results of laboratory investigations of vibration measuring apparatus with direct methods of registration. On the basis of the results obtained, an evaluation is given of the quality of vibrographs of different systems.

N. V. Shebalin. Experience in instrument observations at the central seismic station "Moscow." Tr. Geofiz. in-ta AN SSSR, No. 30(157), 1955.

The paper examines the methods of increasing the accuracy of instrument seismic observations. It is shown that in seismographs of the general type, in the case of

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direct (without shunts) contact of the pendulum with the galvanometer, one cannot ignore the influence of the contact. Distortions of the frequency characteristics, caused by the influence of the contact, are easily eliminated by the proper selection of the damping of the pendulum.

A new method is proposed for determining the normal magnification of siesmographs of the general type. An automatic system is described which is activated by the signal instrument of strong earthquakes and which assures preservation of the record in case of large amplitudes of vibrations.

MICROSEISMS. TSUNAMI

F. I. Monakhov. Microseismic method of tracking sea storms. Vestn. AN SSSR, No. 9, 1955.

The principle of a microseismic method of tracking sea storms is described and its advantages over methods of the hydrometeorological service, which use primarily meteorological observations on land.

An example is given which illustrates the basic concepts of the microseismic method.

F. I. Monakhov. Characterization of the sources of storm microseisms. Izv. AN SSSR, ser. geofiz., No. 6, 1956.

The variation of the intensity of microseisms at the seismic stations of theFar East during the passage of cyclones over the far-eastern seas and the north-western portion of the Pacific Ocean is examined. It is shown that the dominating microseisms are excited near the trajectories of the cyclones.

F. I. Monakhov and V. B. Baryshnikov. Problem of the sources of microseismic vibrations. Meteorologiya i Gidrologiya (Meteorology and Hydrology), No. 4, 1956.

Results are given of an analysis of microseismic records during the passage of two cyclones: 26-27 September 1954 and 9-10 January 1955. The cited observations point out a lag of the source of storm microseisms from the center of the cyclone.

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Ye. F. Savarenskiy, G. A. Proskuryakova, and V. S. Tsirel-Sprintsson. Relationship between microseismic vibrations and the position of cyclones over oceans. Meteorologiya i Gidrologiya, No. 6, 1955.

A determination was made of the direction on the source of microseisms from a station established in the Crimea and near Leningrad. A method was used which is based on the measurement of the time differences of the appearance of the same phase of vibrations on three seismographs situated at the vertexes of a triangle.

P. L. Bezrukov. Certain problems of sediment formation in the Kurile-Kamchatka depression. Byull. Soveta po seysmologii, No. 2, 1956.

Results are presented of complex oceanographic and geological investigations conducted during 1949-1953 by the Institute of Oceanology Acad. Sci. USSR on the expeditionary vessel "Vityaz" in the area of far-eastern seas and the portion of the Pacific Ocean adjacent to Kamchatka and the Kurile Islands.

The investigations made it possible to collect extensive data on the underwater relief and bottom deposits in the Kurile-Kamchatka zone and, in particular, the deep-water depression.

L. M. Brekhovskikh. Tsunami and observations on long-range propagation of sound in the ocean. Byull. Soveta po seysmologii, No. 2, 1956.

The possibilities are examined of short-term forecasting of tsunami by means of observation of sound waves propagating in the depth of the ocean.

V. I. Vlodavets. Tsunami related with volcanic eruptions. Byull. Soveta po seysmologii, No. 2, 1956.

Tsunami caused by the eruption of the Krakatau volcano in 1883 are described. The phenomena which could be the causes of tsunami are analyzed.

Ye. F. Savarenskiy. Problems of tsunami. Byull. Soveta po seysmologii, No. 2, 1956.

The tasks which comprise the problem of tsunami are under-

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scored. Problems related with the propagation of tsunami and methods of notification and protection against them are examined.

A. Ye. Svyatlovskiy. (Tsunami(sea waves during earthquakes)). Tsunami(morskiye volny pri zemletryaseniyakh). Moscow, Acad. Sci. USSR, 1955.

General information is given of tsunami, their occurrence, propagation, and signs of their appearance.

The supplement contains a seismic scale prepared by S. V. Medvedev.

L. N. Sretenskiy. Excitation of elastic vibrations of a semi-plane by wave movements of a liquid. Byull. Soveta po seysmologii, No. 2, 1956.

The problem of the propagation of unsettled sea waves is examined.

In the work, the tsunami are imitated by means of phenomena occurring under the most simple conditions of the Kochi-Poisson problem. Determinations are made of the vibrations which the surface of an elastic semispace undergoes in the case when on the surface of the liquid layer covering it gravitation waves caused by impulse pressure propagate.

N. N. Sysoyev, N. Ye. Mikhal'tsev, G. B. Udintsev, and A. P. Lisitsyn. Prospects of the study of friable sea deposits. Byull. Soveta po Seysmologii, No. 2, 1956.

In connection with the problem of clarification of the nature of waves of tsunami, the causes, and regularities of their occurrence, emphasis is given to the prospects of investigations of the distribution of the thickness and composition of the depth of friable deposits and of the relief of the main channel of the north-western portion of the Pacific Ocean.

G. B. Udintsev. The relief of the Kurile-Kamchatka depression. Byull. Soveta po seysmologii, No. 2, 1956.

The characteristics of the relief of the Kurile-Kamchatka depression are analyzed. The thought is expressed that the deep-water depression and the mountain features of the Kuriles and Kamchatka linked with it should be regarded as a definite geomorphological complex which serves as a surface

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manifestation of the Kurile-Kamchatka geosynclinic system.

BULLETINS OF THE NETWORKS OF SEISMIC STATIONS

Byulleten seti seysmicheskikh stantsiy SSSR(Bulletin of the Network of Seismic Stations of the USS): No. 1, 2, 3 for 1951; No. 4 for 1951. Acad. Sci. USSR, 1952, 1953.

The bulletin contains in a chronological order information on all earthquakes registered by the seismic stations of the Soviet Union.

Byulleten seti seysmicheskikh stantsiy SSSR: No. 1, 2, 3, 4 for 1952; No. 1, 2, 3, 4 for 1953; No. 1, 2, 3, 4 for 1954. Acad. Sci. USSR, 1954.

The bulletin consists of three sections.

The first section gives a chronological list of earthquakes, the position of the epicenters of which has been determined from data of seismic stations. As regards the accuracy of determination, the positions of the epicenter of the earthquakes are divided into two accuracy classes--A and B.

The second section lists data on the times of entry of different waves for all the seismic stations, on the basis of the observations of which the epicenter was determined and also the maximum displacements of the ground in microns.

The third section gives a list of weak local earthquakes recorded, as a rule, by one seismic station.

Byulleten seti seysmicheskikh stantsiy SSSR: No. 1, 2, 3 for 1955. Acad. Sci. USSR, 1956.

The bulletin consists of two main sections: (1) earthquakes of seismically active zones of the USSR; (2) distant earthquakes.

The first section of the bulletin contains data on earthquakes of seismically active zones of the USSR: Carpathian, Crimean, Caucasian, Kopetdag, Central Asian, Baykal, Far Eastern, and Arctic.

The second section of the bulletin contains data on earthquakes, the epicenters of which are situated outside the limits of the indicated seismically active zones.

The earthquakes are classified with respect to the accuracy of the determination of the position of the epicenters.

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Byulleten seysmicheskoy seti Tadzhikistana(Bulletin of the Seismic Network of Tadzhikistan): No. 1(July-Sept) for 1951; No. 2(Oct-Dec) for 1951. Stalinabad. Publishing House, Acad. Sci. Tadzhik SSR, 1952, 1954.

The bulletin contains information on earthquakes registered by the network of seismic stations of the Institute of Seismology Acad. Sci. USSR, and also information on close earthquakes registered by the network of stations of the Geophysical Institute Acad. Sci. USSR, situated on the territory of Tadzhikistan and the stations "Andizhan" and "Fergana"(Uzbek SSR). In individual cases, data from the station "Samarkand" of the Acad. Sci. Uzbek SSR were used for refining the interpretation.

The bulletin of the seismic network of Tadzhikistan,as distinct from the bulletin of the seismic network of the USSR, contains also information on weak earthquakes registered by the seismic stations of the Institute of Seismology Acad. Sci. Tadzhik SSR.

Byulleten seysmicheskoy seti Tadzhikistana: No. 1 (Jan-Mar) for 1952; No. 2(Apr-June) for 1952. Stalinabad. Publishing House, Acad. Sci. Tadzhik SSR, 1953, 1954.

A classification of earthquakes, based on the accuracy of determination of the coordinates of the epicenter, is introduced.

Byulleten seysmicheskoy seti Tadzhikistana: No. 3 (July-Sept) for 1952; No. 4(Oct-Dec) for 1952. Stalinabad. Publishing House, Acad. Sci. Tadzhik SSR, 1954.

Information on distant earthquakes registered by the network of seismic stations of Tadzhikistan is given in the bulletin of seismic network of the USSR and in connection with this, it is excluded from the given bulletin.

Byulleten seysmicheskoy seti Ukrain. SSR(Bulletin of the seismic Network of the Ukrainian SSR): No. 1 for 1952; No. 2 for 1953, No. 3 for 1954. Publishing House Acad. Sci. USSR, 1954, 1955, 1956.

The bulletin contains information on earthquakes registered by the seismic stations of theSeismic Division

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Acad. Sci. Ukrain. SSR, station of the Chernovitsy State University, Kishinev Station(Moldavian Branch, Acad. Sci. USSR) which is situated on the territory of the Carpathian zone. Data are also given on weak jolts, the epicenters of which are situated in the Carpathian Mountains. For an accurate determination of the Carpathian earthquakes, use was made of data from the Crimean network: station Simferopol, Feodosiya, and Yalta.

Kvartal'nyy seysmicheskiy byulleten: No. 1-4(Jan-Dec) for 1947; No. 1-4(Jan-Dec) for 1948; No. 1-4(Jan-Dec) for 1946. Tbilisi. Publishing House, Acad.Sci. Georgian SSR, 1952, 1953, 1954.

The bulletin contains data on earthquakes recorded by the Central Seismic Station in Tbilisi.

The epicenter regions of the Transcaucasian earthquakes are been determined from data of regional seismic stations in the Caucasus and from macroseismic observations.

Seysmicheskiy byulleten regional'nykh stantsiy Gruzinskoy SSR(Seismic Bulletin of Regional Stations of the Georgian SSR), vol. 1, Tbilisi. Publishing House Acad. Sci. Georgian SSR, 1955.

The bulletin contains information on earthquakes registered by regional seismic stations of the Georgian SSR (Gori, Zugdidi, Oni, Central Seismic Station of Tbilisi) whichoccurred during January-December 1939. In order to determine the coordinates of the epicenters, use was made of instrument observations of seismic stations of the Caucasus (Groznyy, Yerevan,Sochi, Pyatigorsk) and also macroseismic data.

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II. SEISMIC GEOLOGY AND SEISMIC DISTRICTING

The Institute of Physics of the Earth of the Academy of Sciences USSR(former Geophysical Institute) has been engaged within the last years with an investigation of the problems of the relationship between geological phenomena and earthquakes(briefly, this field of knowledge can be called seismogeology).

These investigations had a two-fold role. On one hand, using as an example the study of regions of different geological structure and of different degree of seismism, it would be necessary to indicate the relationship between seismic and geological phenomena and to attempt to determine the existing regularities herein, comprehensible as geological criteria of the seismism. On the other hand, using these regularities, it would be necessary to develop methods of geological justification of the maps of seismic districting, as prepared in the Institute by a complex method on the basis of seismological data(observations of the network of seismic stations) and of the above indicated geological data.

Extensive expeditionary investigations in accord with the indicated viewpoint were conducted in the Caucasus, Turkmenistan, northern and southern Tyan-Shan, and Pamir. The literature analysis encompassed also certain other territories--the Urals, part of the Altay, and also regions of Iran, Afghanistan, and China adjoining the USSR.

As a result, certain regular relationships were designated between the seismic and geological phenomena. These relationships and also the data on earthquakes, which were summarized in the recently prepared "Atlas of the seismism of the USSR," were utilized for improving the maps of the seismic districting of the USSR. The preceding map, prepared in 1948, was approved by the Government as a document, mandatory for use in construction in seismic regions. The new improved map was prepared toward the end of 1956.

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III. PHYSICS OF THE EARTH'S CORE

During the past period, investigations in the field of the physics of the inner portions of the globe were continuing along the following main directions: thermal system and thermal history of the earth; mechanical characteristics of the substance comprising the sheaths of the earth; nature of the boundary between the sheaths, physical condition and chemical composition of the sheaths of the earth; processes within the earth and possible paths of the formation of the structure of the earth and of the earth's crust; condition of the substance at high pressures and temperatures, phase changes. We shall give the main results.

THERMAL SYSTEM AND THERMAL HISTORY OF THE EARTH

In the field of study of the geothermal gradient, collection of data has continued. At the present time, geothermal measurements encompass the territories of the Russian platform, East and West Siberia, Caucasus, Donets Basin, Urals, Kola Peninsula, Kurile-Kamchatka chain. Five main regions of the hydrothermal system have been separated (Makarenko and Ivanov, 1956). New methods and apparatus have been developed for the measurement of temperatures with an accuracy of up to 0.01° and various theoretical problems of the thermal investigation of boreholes (Dakhnov and D'yakonov, 1952), (Dergunov and Gorozhankin, 1954), (Belyakov, 1955).

The question is posed regarding the re-examination of the role of volcanoes and hydrotherms in the heat balance of the earth (Lyustikh, 1956).

On the basis of data on the magnitude of the heat flow and the coefficient of heat conductivity of rocks, an evaluation is given of the temperature of the upper lay ers of the earth. At a depth of 100 km, a temperature $\approx$ 1050° was obtained (Magnitskiy, 1953). The same work gives an evaluation of the possible lower boundary of the temperature within the earth, starting from the most unfavorable distribution of the radioactive substances in the earth, zero initial temperature and earth's age of $2 \cdot 10^9$ years.

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Radiogenic heat is taken as the source of the basic source of heat in the investigation of the thermal history of the earth. In connection with this, the evaluation of the age of the earth acquires special significance. An analysis of the isotope composition of leads has shown that the age of the earth's crust is more than $2 \cdot 10^9$ years but less than $5 \cdot 10^9$ years (Vinogradov et al, 1952). For meteorites, an age of 3 to $4.5 \cdot 10^9$ years has been established by the argon method (Rik, 1954; Gerling, 1955).

The main work on the thermal history of the earth was carried out in the Geophysical Institute, Acad. Sci., starting with the cosmogonic hypothesis by O. Yu. Shmidt (1951, 1955). This hypothesis assumes a relatively cold initial condition of the earth which was formed from a gas-dust cloud, which finds its confirmation both in data of observations on the composition of the atmosphere of planets and satellites (Levin, 1953, 1955) as well as in a theoretical analysis of problems of thermal dissipation (Shklovskiy, 1951). An investigation was completed of the warming up of the earth from the impacts of falling particles (Safronov, 1954) and under the action of adiabatic compression in the process of formation. It is established that the maximum initial temperature of the earth was attained in the lower portions of the sheath and was everywhere less than the melting point under corresponding pressures (Lyubimova, 1956). An investigation of the further thermal history of the earth was conducted on the basis of the application of the equation of thermal ~~conductivity~~ diffusivity.

The solution of a heterogeneous equation of thermal diffusivity for a sphere with with a decreasing intensity of the sources of heat was obtained by the method of the Green function which was plotted by the method of reflections in the form of a rapidly decreasing series (Lyubimova, 1952). The temperature in the earth with uniformly distributed sources is given in the form of the difference of two members:

$$T(r,t) = \int_0^t \frac{H(\tau)}{c\rho} d\tau - \frac{k}{r} \int_0^t \frac{H(\tau)}{c\rho} \Phi\left(\frac{R-r}{\sqrt{4k(t-\tau)}}\right) d\tau,$$

where $$H(\tau) = \sum_a H_a(t_0) e^{-\lambda_a t},$$

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$\bar{\Phi}(x)=1-\Phi(x)$; $\Phi(x)$ is the integral of errors; ρ is the density; c is the heat capacity; k is the temperature diffusivity; λ_a is the decomposition constant of the element a, $H_a(t_o)$ is its heat liberation t_o milliards of years ago.

The same method was used to examine also other cases: stratified earth with the gradual inflow of sources into the crust and others(Lyubimova, 1953, 1955a, 1956b). The main conclusions amount to the following: (1) In the temperature field of the earth, during the course of its entire history, one can distinguish a region of the outflow of heat to the surface and an inner region where all the heat is consumed in warming up. The depth of the region of the outflow of the heat is determined by the temperature diffusivity and the time from the moment of the formation of the earth. Now, for k=0.01 CGS, it begins approximately at a depth of about 1000 km. (2) The surface layers have been cooling during the last 2-3 milliard years, but at the same time, below 700 km there is a warming up, which should lead to an expansion of the central portion of the earth. The flow of heat through the surface of the earth, after passing through a maximum, decreases in the course of 2-3 milliard years. The calculated value of the flow coincides with the measured value, if the age of the earth is taken as 4-5 milliard years. (3) The earth as a whole could not have melted in the process of warming up due to the high pressure at the depth. The nearness of the temperature to the melting point(Magnitskiy, 1956) in the upper portions of the sheath indicates the possibility of the formation of magmatic centers. The temperature distribution in th e earth's core is in agreement with the Bullen hypothesis of the solid, inner core and its liquid outer portion(Lyubimova, 1956a). Complete melting, however, is possible for bodies of smaller size, for example, the moon(Levin and Lyubimova, 1955). For asteroids, melting is possible only in the case of the central portion(Lyubimova and Starkova, 1954).

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MECHANICAL CHARACTERISTICS OF THE SUBSTANCE OF THE EARTH'S SHEATHS

Themain investigations in this field deal with the study of the distribution of the density, modulus of compression, and hardness with depth. The greatest progress in this field was attained in the works of M. S. Molodenskiy. Equations have been obtained for the deformation of an elastic, heterogeneous, compressible, and gravitating sphere. Different models of the earth are examined, both with a liquid as well as with an elastic core and with different laws for the density. The equations of the elastic equilibrium have the following form:

$$-\left[\mu\left(T'+H-\frac{2}{r}T\right)\right]'=\rho\left(R+V'H\right)+\lambda f+$$
$$+2\frac{\mu}{r}\left[2H+T'-\frac{n^2+n+1}{r}T\right];$$
$$-\left(\lambda f+2\mu H'\right)'=\rho\left(R'+V'H\right)'-\rho V'f+$$
$$+4\frac{\mu}{r}\left(H'-\frac{H}{r}\right)-\frac{n(n+1)}{r^2}\mu\left(T'+H-4\frac{T}{r}\right);$$
$$R''=-\frac{2}{r}R'+\frac{n(n+1)}{r^2}R+4\pi\kappa\left(\rho f+\rho' H\right),$$

where H characterizes the radial displacement, T is the tangential, and R is the variation of the potential as a result of the deformation of the sphere; V is the potential.

The numerical integration of the equations has made it possible to establish that, for the existing law of the variation of the velocities of seismic waves, for all the models, the value of the ratio of the Ly av numbers k/h=1/2 is valid. For an evaluation of the mechanical properties of the core, use can be made of the results of the observations of theinflow(tide) slopes, variations of the force of gravity, and period of free nutation. The problem of calculating corrections for the mobility of the waters in the oceans is re-examined. Only the period of free nutation makes it possible at the present time to make conclusions about the condition of the core of the earth. It was found that, within the limits of the accuracy, two variants are possible: $\mu=0$ and $\mu=0.6\cdot10^{12}$ dynes/cm.^{2} Refinement of the theory and determination from the observations of the amplitudes of forced nutation of different periods will permit in the future to solve the problem whether the core of the earth is liquid or solid(M. S. Molodenskiy, 1953).

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Investigations were made of the free nutation in order to refine the information on the mechanical characteristics of the core. It was established that the nutation constant is less than the theoretical, as calculated for an elastic core, by 0".020. The theoretical ratio of the axes of the ellipse of nutation coincides with the observed one. The retardation in phase is observed only in nutation along the longitude. The semi-daily(12-hr) wave in the variations of the latitude is given by the formula

$$\Delta\varphi = 0''{,}0090 \underset{\pm 14}{} \sin\left(2\Theta - \theta - \underset{\pm 2}{10^\circ}\right) + 0''{,}0027 \underset{\pm 7}{} \sin(2\Theta + \theta + \underset{\pm 16}{9^\circ})$$

instead of

$$\Delta\varphi = 0''{,}0051 \sin(2\Theta - \theta)$$

for an ideally elastic earth, where Θ is the average longitude of the moon, θ is the local star time. (Fedorov, 1951, 1955.)

A continuation of the investigations of M. S. Molodenskiy made it possible to obtain new limits for the density within the earth, much more narrow than the Rado limits(Molodenskiy, 1955). Moreover, it was shown that the maximum jump in the density on the boundary of the earth's core cannot exceed 4.6 gm/cm.^{3}

The investigation of the nature of the reflections of seismic waves from the boundary of the earth's core tends to favor the liquid core; at any rate, the modulus of hardness of the core cannot exceed 10% of its value in the sheath (Savarenskiy and Kirnos, 1955).

Various investigations were carried out on the application of the theory of non-ideal elasticity to explain the mechanical characteristics of the earth. Three-dimensional equations were obtained for the propagation of waves in an elastic-viscous medium(Gurevich, 1955). Starting with the Maxwell theory and seismic data, an attempt was made to evaluate the viscosity of the earth's core; the value obtained was $\eta < 10^{14}$ poises(Magnitskiy, 1953); an analogous result was obtained also on the basis of the "hole" theory of the liquid state(Frenkel, 1950).

The equation obtained was

$$\frac{d^2\sigma}{dt^2} + \frac{1}{\tau_1}(1+\alpha)\frac{d\sigma}{dt} + \frac{a}{\tau_1\tau_2}\sigma = \mu\frac{d^2\varepsilon}{dt^2} + \frac{a\mu}{\tau_1}\cdot\frac{d\varepsilon}{dt}$$

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which generalizes the Maxwell equation for the case of a medium with strengthening and with two different periods of relation τ_1 and τ_2, where σ is the stress, ϵ is the deformation, and α is the ratio of the coefficient of strengthening to the modulus of hardening. An attempt was made evaluate the magnitude of both periods of relaxation ~~x~~ for the ~~xxxx~~ sheath of the earth; the values obtained were $\tau \approx 10^3$ years and $\tau_2 \approx 10^9$ years(Magnitskiy, 1955). Such a medium behaves like a medium with a finite fundamental strength; only for times greater than 10^9 years, does it behave similarly to a Maxwell medium. The results are applicable to the evaluation of the time necessary for the occurrence of certain earthquakes(Magnitskiy, 1953, 1955), (Savarenskiy and Kirnos, 1955).

A comparison was made of the gravimetric data with those of the volumes of rocks transferable along the earth's surface. The conclusion was derived that, at a certain depth under the earth's crust, processes of overflowing of the sub-crust substance should take place(Magnitskiy, 1953). From an analysis of gravimetric data, a conclusion was derived about the existence of heterogeneities in the horizontal direction in the sheath of the earth at considerable depths(Lyustikh, 1954).

Starting with the theory of a solid body, calculation was made, from the formulas for ionic crystals, of the modulus of compression K and density for the sheath of the earth. The resulting data are compared with data on seismology. They show sufficiently satisfactory agreement with the results obtained by Bullen(Magnitskiy, 1952, 1953, 1955).

NATURE OF BOUNDARIES BETWEEN SHEATHS, PHYSICAL CONDITION, AND CHEMICAL COMPOSITION OF THE EARTH'S SHEATHS

The investigations of K and ρ, mentioned in the preceding section, made it possible to come to the conclusion of the heterogeneity of the earth's sheath: there is either a change in the chemical composition or a polymorphic transformation

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in the layer C. The hypothesis of the ordinary polymorphic transformation is shown to have little basis, both from the point of view of the theory as well as in the light of experimental data. It is shown that the layer D can consist essentially of magnesium and iron oxides with a small admixture of other compounds. A thermodynamic analysis of the problem of the stability of certain silicates and oxides at high pressures turned out to be in agreement with the latter view(Magnitskiy, 1952, 1955).

An investigation was made of the total chemical composition of the earth on the basis of a re-examination of the available data on meteorites. The following percentage contents of the basic elements of the earth were obtained: O--34.6, Fe--25.6; Si--17.8; Mg--13.9; S--2.0; Ca--1.6; Ni--1.4; Al--1.4(Levin, 1954, 1955). The problem of the composition of the earth's crust was re-examined(Vinogradov, 1950). The problem of the ~~composition~~ comparison of the composition of the earth with other planets was examined. Satisfactory agreement is obtained, if one starts with the hypothesis of the origin of the earth from a cold, gas-dust cloud. An explanation is given for the shortage on the earth of nitrogen and especially of the inert gases, which is that, being in a gaseous state, they could not, in considerable amounts, enter into the composition of the earth during its formation(Levin, 1953, 1955). The above-cited composition of the earth is not in agreement with the hypothesis of an iron core. A re-examination was made of theproblem of the composition of the earth's core. Various arguments are advanced in favor of the Lodochnikov-Ramsey hypothesis that the movement to the core is caused by a phase change of the silicates of the sheath into a metallic state(Levin, 1955). The hypothesis is advanced that in the core there takes place complete destruction of the electronic sheaths, the chemical elements become indistinguishable, and the reactions impossible(Kapustinskiy, 1956). It is pointed out that in the sheath there is possible a transfer of electrons to the incompletely occupied levels and, in connection with this,

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an anomalous chemism of certain elements(Magnitskiy, 1952, 1953), (Kapustinskiy, 1956).

Since the hypothesis of the oxide composition of layer D is in poor agreement with the composition of the earth, while the hypothesis of the simple polymorphic transformation is highly improbable and does not explain the special characteristics of layer C, it was proposed to explain the special characteristics of layer C by the circumstance that, under conditions of pressure and temperature, there occurs in this layer a rapid but continuous transformation of substance from a state with a predominance of the ionic type to a state with a predominance of the covalent type of bond, thanks to the strong overdischarge of the electronic clouds of atoms. The jump in k/ρ obtained by this method was in good agreement with that obtained by seismic data, while the jump of 18% in density as calculated from the covalent radii, was also in sufficiently good agreement with the data on the density of the earth (Magnitskiy, 1956a).

PROCESSES WITHIN THE EARTH AND POSSIBLE PATHS OF FORMATION OF THE STRUCTURE OF THE EARTH AND OF THE EARTH'S CRUST

The main attention was directed to an explanation of the regularities of the geotectonic process of development of the structure of the earth's crust. V. V. Belousov, in the book "Osnovnyye voprosy geotektoniki"(Basic problems of geotectonics), presented the system of views on the mutual relationships between the different tectonic movements and also the regularities in their succession and directivity. Slow vertical ascents and descents of the earth's crust(vibration movements) are regarded as the most common form of tectogenesis, whereas folded and discontinuous movements are regarded as secondary and derivative. Any substantial role of horizontal stresses in the earth's crust is denied. As a basic deep process, that of the differentiation of the substance of the earth is proposed; this is shared also by other investigators(Belousov, 1951, 1954, 1955a, 1956b), (Kropotkin, 1950, 1953, 1956), (Magnitskiy, 1953, 1956). V. V. Belousov advanced the idea of a multi-storied

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differentiation of the substance of the earth's crust with respect to density, which makes it possible to approach an explanation of the observed interrelationships between the geosynclinal and the platforms. An examination is made of the possibility of a new, strong activation of tectonic movements after the platform stage, which, in turn, replaced the geosynclinal stage. Tyan-Shan represents, for example, such an activated platform.

Different viewpoints are expressed regarding the history of continents and oceans. V. V. Belousov sees in the oceans relatively young formations which developed in the place of former continents and small seas in connection with the "basification" of the earth's crust and he assumes that the increase in the amount of water on the earth is due to deep sources(Belousov, 1956b).

Another hypothesis considers that, in the course of the history of the earth, there was a gradual expansion of the continental type of the earth's crust due to the ingress of still new amounts of SiO_2 and Al; moreover, the general directivity of the development of the crust was in the direction of the expansion of the continents at the expense of a decrease in the area of theoceans(Kropotkin, 1950, 1953, 1956), (Magnitskiy, 1953, 1956b).

The basic deep-level process is regarded to be the process of decomposition of $MgSiO_3$ in accordance with

$$2MgSiO_3 \longrightarrow Mg_2SiO_4 + SiO_2$$

and the further process of gravitation differentiation which leads to ascent of SiO_2 to the surface and the formation of the crust(Magnitskiy, 1952, 1953, 1955). Special attention is dealt to the problem of the origin of basalt and granite magmas; their melting from the solid sheath of ~~peridotite~~ peridotite-pyroxene composition as eutectic compositions (Kropotkin, 1953, 1955).

On the basis of an analysis of the gravitation field of the earth, the view is advanced that the variation in the

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density of the substance of the earth's sheath(Magnitskiy, 1953, Subbotin, 1955) is the basic cause of the vertical vibration movements of the earth's crust. The sub-crust overflowing of the substance, even though it exists, is a secondary process.

On the basis of an analysis of gravitation data, the condition is established of approximate isostatic compensation for large blocks of the earth's crust. At the same time, the concept of the leading nature of the process of isostatic equilibration during the course of the formation of the earth's crust is subjected to a critique. The Wening-Meines hypothesis of theformation of orogen by lateral pressing down of the sialic crust and its buckling downward is shown to be invalid. The zones of negative anomalies along the insular arcs are explained by the accumulation of light material in the process of movement from the depth of the products of differentiation in the regions of the active geosynclinal process(Lyustikh, 1955a, 1956b), (Yevseyev, 1954). Another cause of the occurrence of zones of negative gravitation anomalies can be the process of the extension of the earth's crust with the settling therein of its blocks in the form of wedges with subsequent filling of the resulting depressions with light alluvia(Magnitskiy, 1953).

CONDITION OF THE SUBSTANCE AT HIGH PRESSURES AND TEMPERATURES

PHASE CHANGES

Starting with the principles of quantum mechanics, an examination was made of phase changes under the action of high pressures. Calculation was made of the change of hydrogen into a metallic phase, which refines the data of previous works. It was found that hydrogen changes into a metallic phase under pressures of 1,850,000 atmospheres; the density,thereby, changes from 0.7 to 0.96. The difference from the results by Kronig, de Boor, and Poring is explained by the circumstance that they started from the stepwise de Boor formula which, under these conditions, gives false results. The above-cited data were obtained by rigid calculation of the corresponding integrals(Davydov, 1955).

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Formulas were obtained for the energy and equations of the state for different types of solid bodies, which satisfy the experimental data for the entire range of pressures of the experiment. The formulas for the energy have the form of:

(1) ionic crystals $E = Ae - BV^{1/3} - CV^{-1/3}$

(valence crystals $E = (CV^{-1/3} - A)e - BV^{1/3}$

(3) molecular crystals $E = Ae - BV^{1/3} - CV^{-2}$

(4) metals $E = Ae - BV^{1/3} - CV^{-1/3} + DV^{-2/3}$

where V is the volume and the remaining symbols are constants. The temperature correction is based on the ordinary Debye theory(Davydov, 1956).

Experimental work on the study of the characteristics of rocks under great pressures, as carried out in the Gephysical Institute Acad. Sci., have shown that the velocities of seismic waves in covered specimens for basalt, gabbro, syenite, sandstone, marble increase considerably up to pressures of 1000 kg/cm^2, which is connected with the closure of the pores in this range of pressures; with a further increase in pressure to 5000 kg/cm^2, there is only a very small increase in the velocities(Volarovich, Balashov, and Stakhovskaya, 1956). Investigations of thin plates of rocks by the Bridgman method, using a pressure up to 40,000 kg/cm^2 on one side, with simultaneous twisting, has shown the existence of explosive effects; moreover, the explosions in igneous rocks were observed ordinarily at lower pressures than in such sedimentary rocks as sandstone, limestone (Volarovich, Gorozdovskiy, and Parkhomenko, 1953).

Investigations were also carried out of the piezo-electric effect of igneous rocks, which could serve as an explanation for certain seismoelectric phenomena(Volarovich and Parkhomenko, 1954, 1955).

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IV. TECTONIC PHYSICS

The study of the mechanism of the development of tectonic deformations and faults is called tectonic physics in the USSR. The object of the investigation is tectonic (geological), the arrangement of the problems and the methods of their solution should be both tectonic(field observations) as well as physical(laboratory tests, miniaturization, theoretical analysis).

Tectono-physical investigations are carried on in the USSR in connection with the study of the basic regularities in the development of the earth and the clarification of the causes of tectonic processes; in connection with the development of a method of seismic districting and the searches for a method of forecasting the time of earthquakes and in connection with the refinement of methods of searching, surveying, and developing deposits of metals, oil, coal, and structural materials.

The first laboratory in the USSR which is systematically engaged in problems of tectonic physics was organized by V. V. Belousov in 1944 in the Institute of Theoretical Geophysics Acad. Sci. USSR(presently the Institute of Physics of the Earth, Acad. Sci. USSR). Then. in 1954 the tectono-physical laboratories were established by the Moscow State University imeni M. V. Lomonosov and by the Ministry of the Oil Industry USSR. In addition, work is being conducted in many other scientific organizations along individual directions of tectonic physics.

The Institute of Physics of the Earth Acad. Sci. USSR, under the leadership of V. V. Belousov, is conducting expeditions which study themechanism of the formation of folds and faults in the tectonically most mobile portions of the earth's crust; examinations are made of th e principal general problems of tectonic physics and a procedure of investigations is being developed; miniaturization is being carried on(Gzovskiy, Sorskiy, Kirillova, Ez, Chertkova, Osokina). The same institute is making studies of the mechanical and other physical characteristics of rocks under high pressures from all sides(Volarovich). The enumerated

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~~high pressures from all sides(Velarovich. The enumerated~~ works are conducted with the aim of solving the problem of fold ~~formx~~ formation(clarification of the causes and mechanism of the formation of folds in the earth's crust) and in connection with the study of earthquakes and seismic districting.

The Institute of Geology of Mineral Deposits Acad. Sci. USSR is studying by field methods the mechanism of the formation of the structure of vein ore deposits and the influence of this process on the formation of ore deposits~~xxx~~ (Vol'fson, Lukin, Kushnarev) and an investigation is being conducted of the fissure tectonics of the deposits of structural materials(Belikov). The method of petrotectonics (Lukin) is being utilized to solve these problems. The laboratory is making a study of the relationship between the mechanical characteristics and the peculiarities of the lithology of rocks(Zalesskiy, Rozanov).

In the Geological Institute of the Academy of Sciences Ukrainian SSR, N. P. Semenenko, Ya. N. Belevtsev, and G. V. Tokhtuyev are studying small folding and the cleavage in iron ore of the pre-Cambrian quartzites.

The regularities of the formation of faults are being investigated in the research institutes of the Ministry of Geology and Protection of Resources(Kreyter), Ministry of Oil Industry(Permyakov), Ministry of Non-Ferrous Metallurgy(Borodayevskiy), and Ministry of Chemical Indsutry(Virovlyanskiy) in order to develop methods of searching and prospecting deposits of oil, non-ferrous metals, gold, and other minerals.

In the Moscow State University imeni M. V. Lomonosov, under the leadership of V. V. Belousov, field methods and miniaturization are used for the study of cupola-like folds, and in particular, the mech anism of the floating of salt cupolas(domes). Ye. A. Kuznetsov is working in the field of petrotectonics and G. D. Azhgirey is studying the mechanism of the formation of folds and large faults. The

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Moscow Geological-Prospecting Institute imeni S. Ordzhonikidze is conducting investigations of the mechanism of the formation of folds(Bronguleyev) and cleavage (Mikhaylov). A. A. Trofimov is studying the tendency of [illegible] coal-bearing deposits to crack. The Moscow Training Institute of Non-Ferrous Metals and Gold, under the leadership of V. M. Kreyter and F.I. Vol'fson, is studying the influence of the process of development of the structure of the earth's crust on the formation of ore deposits. In the Leningrad State University imeni A. A. Zhdanov, N. A. Yeliseyev is carrying on work in the field of petrotectonics. In the Novocherkass Polytechnic Institute, A.V.Pek is studying the structure of ore deposits and is engaged with petrotectonics. In the Irkutsk State University, V. N. Danilovich is engaged with problems of the mechanism of the formation of folds and faults. In the Novosibirsk Polytechnic Institute, A. A. Belitskiy is studying the fracturing of coal deposits.

Up to 1949-1950, the tectonophysical work in the USSR consisted essentially of a study of the mechanism of the formation of small folding and the study of fissured tectonics and petrotectonic investigations.

The results of the study of small folding are presented in the works of V. V. Belousov, I. V. Kirillova, A. A. Sorskiy, and V. V. Bronguleyev(12-14, 26, 72, 118-120). The origin of small folding was explained by the circumstance that rocks are squeezed out along the cleavage from one of the places and is forced into other places where the folds form. The idea was advanced that, in the process of fold formation, the leading role is played by the overflowing of relatively least viscous ("non-competent") layers. The widespread notion regarding the leading role of bending deformation relative the most viscous("competent") layers was placed in doubt. The idea was advanced regarding the possibility of separation in the earth's crust of alternating regions of squeezing out with

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their characteristics phenomena of a decrease in the thickness of the layers and boudinage and of regions of pressing-in in which the folds form. Data were cited in favor of the adoption of this method for large folds. The substantial factor in this is the circumstance that th e horizontal forces which directly create each fold are regarded as the result of the action of the vertical forces on the layers of the earth's crust. The crumpling of the layers into folds was not connected with the general compression of the entire geosynclinal region between the more rigid platform regions which surround it. Fold formation was considered a local phenomenon which develops within the geosynclinal region on its individual sections. It can proceed independently of the deformations of of other sections of the geosynclinal. The given concept is connected with the general system of tectonic ideas by V. V. Belousov regarding the development of the earth, in which the main importance is given to the vertical tectonic forces and movements.

Among the results of the study of tectonic faults, the work by Ye. N. Permyakov stands out(105). It proposes a new method for searching for cupola-like folds and platform, oil-bearing regions. The method consists of a unique interpretation of the tectonic fracturing of the rocks of the sedimentary cover of the platform.

Starting in 1950, tectonophysical investigations in the USSR were considerably expanded.

Efforts were made to refine the physical bases of tectonic physics. Attention was being paid to the study of the mechanical characteristics of rocks and the relationships between these characteristics and the lithological peculiarities of rocks(Volarovich, Zalesskiy, Rozanov, et al.--5, 29-31, 51, 52, 67, 77).

Much higher requirements were imposed upon laboratory

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miniaturization of tectonic processes. Attempts were made to develop new conditions of similarity; investigations were started of the mechanical characteristics of the already employed materials and also searches for new materials, the equivalents of the rocks used in the models. An optical method was employed to investigate stresses in the models(Gzovskiy--43, 45, 47, 49, 50).

A joint study was made of the mechanism of formation of large and small structural forms(folds and faults) on the background of the geological history of the territories under investigation(Central Asia, Caucasus).

As a result of observations in the West Alps, V. V. Belousov(17) proposed to separate three basic types of folding on the basis of kinematic signs: block, folding of pressing-in, and folding of crumpling. V. V. Belousov is of the opinion that the folding of the different forms as a result of the deformation which develop in the plastic, lamellar depth as a complication of the vertical movements of the individual sections of the earth's crust. The deformations are caused directly by two factors: vertical hammering during the upheavals with the squeezing out of the material to the sides and by the force of gravity.

An examination was made of the basic ideas of tectonic faults and methods of their study. Upto 1948-1949, Soviet geological works made wide use of the G. Bekker concept of the coincidence of the cracks of cleaving with circular cross sections of the ellipsoid of deformation. Starting in 1949, there appeared several critical comments directed at this concept(Kosygin, Luchitskiy, Rozanov, Belitskiy, Gzovskiy, Gurevich, and others, 10, 43, 44, 46, 55, 57, 64, 66, 77, 112). In order to explain the physical conditions of the formation of the tectonic faults, use was made of the hypothesis of maximum tangential stresses(Belitskiy, Belousov, Mikhaylov--10, 11, 15, 16, 97). Then, M. V. Gzovskiy proposed a new complex notion of the physical

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conditions of the occurrence of the faults, which combines various hypotheses of the strength and takes into account the presently known results of tests of rocks(43, 44, 46, 49).

By means of a field study of natural objects and as a result of miniaturization, it became clear that the formation of a large fault represents a long and complex process. Small, initially disconnected, faults expand, gradually combining into a large disturbance(15, 16, 42, 48, 50, 127). This concept is one of the bases for searching for forerunners of earthquakes(Belousov, Gzovskiy--18, 42, 49).

Attempts were made to study the tectonic fields of stresses acting in the earth's crust and which produce tectonic faults. Principles were formulated for conducting field investigations in order to clarify the basic characteristics of such fields of stresses(Gzovskiy, 44, 45).

Use was madeof an historical approach to the study of the structure of ore fields. By creating anew the history of development of tectonic deformations, attempts were made to establish the place of mineralization in the general process of the development of tectonic and magmatic phenomena(Kreyter, Vol'fson, Kushnarev, Lukin, Borodayevskiy, and others--22, 23, 32, 41, 80).

The changes in the concepts of the mechanism of the formation of folds and faults and the appearance of new geological materials have led to the need of re-examining the classification of folds and faults. These problems are discussed in various works of V. V. Belousov, A. A. Belitskiy, M. V. Gzovskiy, V. Ye. Khain, G. D. Azhgirey, V. V. Bronguleyev, A. Ye. Mikhaylov, and others(1, 11, 15, 16, 27, 43, 46, 96, 123).

Finally, one should mention the attempts to obtain a mathematical solution of certain tectonophysical problems. Yu. A. Kosygin and B. L. Shneyerson(129-131) examined the process of the growth of salt cupolas and G. I. Gurevich(56)--th e mechanism of [redacted] boudinage.

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V. DETERMINATION OF THE ABSOLUTE AGE OF ROCKS AND MINERALS IN THE USSR

Systematic investigations of the age of rocks and minerals by radioactive methods, which have great theoretical and practical significance, were started in the USSR in 1924 by the founder of geochemistry and radiochemistry, academician V. I. Vernadskiy and his student, academician V. G.Khlopin.

During the last five years, these works received particularly intensive development in the institutes of the Acad. Sci. USSR, academies of sciences of the union republics, certain branches of the Acad. Sci. USSR, and various industrial research institutes.

It is rather important that during this period, all the works of the indicated direction were and are being conducted in accordance with a general plan. In order to combine the geochronological investigations, which are being conducted by different laboratories and in order to give them a single directivity, the work of the commission for the determination of the absolute age of geological formations(attached to the OGGN, Acad. Sci. USSR) was stregthened.

Academician V. I. Vernadskiy was one of the first in the world to evaluate the great sicentific and practical significance of radioactive methods for determining the age of geological formations. He created the science of radiogeology, which he briefly characterized as: "Radiogeology the course of radioactive processes in our planet, their reflection, and manifestation in geological phenomena."

V. I. Vernadskiy saw the basic task of radiology as the establishment of the absolute chronology of geological phenomena, based on the phenomena of radioactive decomposition and the accumulation in minerals and rocks of finite products of decomposition--lead, helium, in amounts which are a function of time. He pointed out two problems in this field: determination of the duration of geological processes and determination of the age of geological layers. Convinced ~~of the importance of chronology~~

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of the importance of absolute chronology, V.I. Vernadskiy organized the work in this field in the Radium Institute, Acad. Sci. USSR, where the first figures were obtained for the USSR. Here also, an experimental procedure was refined and substantial corrections were introduced into the formulas which were used for calculations. The works of academician V. G. Khlopin and his school, along with the systematic determination of the absolute age of minerals and rocks of different districts of the Soviet Union, advanced various original procedures, among which the xenon method(xenon is the product of the spontaneous fission of uranium-235) is of great fundamental significance.

At the present time in the Soviet Union, various radioactive methods have been developed and tested in practice; among these, the lead method with mandatory mass spectrographic determination of the isotope composition of the leads separated from the mineral is of greatest importance.

In 1936, I. Ye. Starik proposed an method for determining the age of the earth from the ratio of the isotopes of lead-206 and lead-207 and he made calculations of the age from data by Aston. In 1952, in the Institute of Geochemistry and Analytical Chemistry imeni V. I. Vernadskiy, Acad. Sci. USSR, under the leadership of academician A. P. Vinogradov, new experimental data were obtained on theisotope composition of ore leads and, on the basis of these, new calculations were made of the age of the earth. The most probable age of the earth is determined as 5 milliard years at the given moment.

The lead method, which serves for determining long periods of time, has great advanatages over other methods because it is possible simultaneously to obtain four values of the ratios of lead-206 to uranium, lead-207 to actino-uranium, lead-208 to thorium, and lead-207 to lead-206 for the determinable age, while the convergence of these values provides great confidence in the correctness of the results.

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It is necessary to point out that, in various cases, the ages obtained from different ratios can differ. It is observed that the ages, as calculated for certain uraninites from the ratio of lead-206 to uranium and lead-208 to thorium, differ. In the case of monazite, the most probable age considered is that calculated from the ratio of lead-208 to thorium.

In 1947, in the Institute of Geological Studies, Acad. Sci. USSR, I. B. Borovskiy developed a roentgen-spectral method for determining the age (using the lead method). The roentgen-spectral method made it possible to directly determine three ratios between uranium, thorium, and lead, by-passing the determination of their absolute amounts. In practice, this method is used to determine the age of minerals within the limits of 150 to 2000 million years.

In the roentgen-spectral determination of the age, there is a sharp decrease in the amount of stone material (to 50-30 and even to 10 mgm) necessary for analysis.

The selective check during several years of the figures of the absolute age, as obtained by chemical, radiochemical, mass spectrometric, and roentgenospectral methods, has shown good convergence of the results.

In 1950, in the Laboratory of Post-Cambrian Geology, Acad. Sci. USSR, E. K. Gerling started work on the determination of the age of minerals and rocks and also of stone meteorites by the argon methods.

As is known, the argon method is based on the determination of the ratio of Ar^{40} to K^{40} (Ar^{40} forms from K^{40} from the reaction of $K^{40} + e \longrightarrow Ar^{40}$).

The argon method can be applied in the determination of the age of potassium minerals of the most diverse genesis.

In order to determine the age of a mineral u nder

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investigation, it is necessary to know the content of argon and the amount of potassium therein. Potassium in minerals is determined by the ordinary chemical means, while the determination of argon is made with a mass spectrometer.

On the basis of numerous determinations of the age by the argon method, it has been established that the age values obtained with young minerals and rocks are in good agreement with the geological concepts, while in the case of ancient geological formations, lower age figures are obtained, which is caused by their noticeable loss of radiogenic argon.

The minerals that are suitable for the determination of their age by theargon method have not yet been established.

E. K. Gerling believes that mica is the most suitable mineral, while N. I. Polevaya(VSEGEI) believes that potassium feldspars and granites, as a whole, can be utilized for the determination of the age of young geological formations by theargon method.

In the Daghestan Branch, Acad. Sci. USSR, a rapid method was developed for determining the age of geological formations from the radioactive decomposition of potassium-40 into argon-40.

Kh. I. Amirkhanov and I. G. Gurvich are the authors of a rapid mass spectrometric method for determining the radiogenic argon of geological formations. They developed the basic problems of the theory of the method of isotope dilution and further paths are mapped out for the development of the procedure.

In Alma-Ata, in the Kazakh University imeni S. M. Kirov, V. V. Cherdyntsev is developing a method for determining the age of young formations from the actinium-radium method and thorium isotopes.

The rubidium-strontium, carbon methods h ave not yet been developed widely in the USSR.

In the study of minerals, from which age determinations

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are made, their interaction with the surrounding medium should be considered.

The basic cause of erroneous data, obtained in the determination of the age by radioactive methods, is the poor preservation of the test specimen as a result of secondary processes taking place under natural conditions.

These processes include the phenomena of migration of radioelements, different extent of leaching-out of individual radioelements, and emanation, as a result of which, the radioactive equilibrium is disturbed. It is naturally impossible to determine the age of such specimens.

I. Ye. Starik proposed a method for determining the emanation capacity as a criterion of the suitability of the mineral for determining the age by the lead method--a large coefficient of the emanation capacity indicates poor preservation of the specimen.

In order to have the possibility of utilizing the radioactive decomposition for the determination of the age, the following conditions are necessary:

1. The radioactive decomposition should proceed in the geological time with a constant speed within the limits of the accuracy of the determination of the decomposition constant.

2. The final decomposition products should be stable.

3. In the geological time, there were no nuclear reactions unknown to us, which lead to the formation of elements from which the age determination is made.

4. The accurate values of the decomposition constants of the maternal substances are known.

5. The content of radioelements, on the basis of which the age is calculated, is subject to accurate determination.

6. The processes, which disturbed the radioactive equilibrium in the test specimen, are lacking.

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It is also necessary to know the isotope composition of the radioelements which is the ancestor of the radioactive series. At the given time, the physical concepts, based on experimental data, make it possible to accept the speed of radioactive decomposition in the course of geological time as a practically constant value within the limits of accuracy of contemporary methods of investigation.

The isotope composition of the ancestors of radioactive series can be considered as established. The final products of decomposition(lead and helium) are also stable practically. The sensitivity of the methods for the determination of the radioactivity is at present very high; it is possible to detect elements with a period of semi-decomposition(half life) of the order of 10^{14}--10^{15} years.

The isotopes of lutecium, rhenium, and others h ave a similar period of semi-decomposition and they cannot alter the results of age determination, conducted from radioactive elements with a considerably smaller period of semi-decomposition.

At the present time, the accuracy of determination of radioactive constants for most radioactive elements is sufficient for practical purposes of the age.

In addition to observance of the enumarated conditions in order to obtain correct values of the age, which are common for all the radioactive methods, there are conditions which are characteristic for each method in particular: for example, in the lead method, the error in the determination of the age can be connected with the entry of ordinary lead into the minerals etc.

In the Radium Institute imeni V. G.Khlopin, Acad. Sci. USSR and in the Institute of Geochemistry and Analytical Chemistry imeni V. I. Vernadskiy, Acad. Sci. USSR, investigations are being carried on of the study of the

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processes of migration of radioactive elements and their decomposition products in order to learn the causes of the displacement of the isotope ratios in the lead method for the uranium and also for the thorium minerals.

The commission to determine the absolute age of geological formations(attached to the OGGN, Acad.Sci. USSR) is faced with the following basic tasks:

1. Development of a domestic scale expressing absolute chronology.

2. Dating of the main tectono-magmatic stages of the geosynclinal zones of the territory of the Soviet Union in absolute chronology.

Work in both of the indicated directions is being conducted in a complex manner, with the participation of stratigraphers, tectonists, petrographers, geochemists, radiologists, chemists, and geophysicists, with the application of different radioactive methods for the determination of the age by complex investigations.

The material for solving the indicated problems is obtained by a study of the sections in geosynclinal zones of the earth's crust, which contain magmatic inclusions.

Upon the decision of the commission the investigations to determine the absolute age were started on Pre-Cambrian deposits of the Baltic and Ukrainian crystalline shields.

In the case of the Pre-Cambrian rocks of Karelia, geologists separate four large magmatic cycles. The first three of these are related with three geosynclinal cycles and with the formation of the corresponding folded zones; the fourth cycle pertains to that time when the territory of the Baltic schield was a platform, while the magmatic rocks of the fourth cycle are included in the fractures.

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At the present time, the age of minerals from pegmatites of the White Sea formation of the Baltic crystalline shield can be considered as finally established and accepted. This age turned out to be equal to 1800 million years from repeated determinations in the Radium Institute imeni V. G. Khlopin by the lead method with mass spectroscopic determinations of the isotope composition of lead on the minerals uraninite, monazite, and wiikite and from several determinations of the Laboratory of ~~Kmsk~~ Pre-Cambrian Geology, Acad. Sci. USSR, which were made with micas by the argon method. This figure of 1800 million years is of interest in that more than 30 years ago K. A. Nenadkevich was the first to determine the age of pegmatites of the White Sea formation of Northern Karelia, while investigating the ratio of lead to uranium in uraninite, having determined the atomic weight of lead separated from uraninite.

V. G. Khlopin and M. Ye. Vladimirova, having made 17 determinations from minerals of different pegmatite veins of Northern Karelia, obtained the figure of 1800 million years.

And only at thepresent time, after mass spectroscopic ~~determinations~~ investigations have been made of the leads separated from uraninite(this work was performed by G. V. Avzdeyko under the direction of I. Ye. Starik and G. R. Rik), is it possible to be confident of this figure which dates the most ancient geological formations of the earth's crust.

The results of the determination of the age, obtained for White Sea pegmatites, are approached, as regards reliability, to a considerable extent by the figures obtained for the Azov area with monazites by L. V. Komlev--1950 million years, as calculated from the ratio of lead-207 to actinium-uranium, and 1830 million years obtained from the ratio of lead-208 to thorium. The data of theisotope ratio of lead-208 to thorium for three samples are in good agreement with this value.

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Numerous determinations of the age of minerals and rocks by the argon method, as performed by E. K. Gerling and N. I. Polevaya for Pre-Cambrian deposits of the Baltic and Ukrainian shields and the outcrop of the most ancient formations in the Mamsk district, do not agree in various cases with the geological concepts. Thus, the new figure of 1500 million years obtained for rapakiwi-granite is considered very high by academician A. A. Polkanov; the time interval between the intrusions I and IV groups of rapakiwi-granite is measured altogether as 300-350 million years(group II of granites--1800 million years, group IV of granites--1500 million years), while the interval between the age of rapakiwi and kolm is 1000 million years(group III of granites--1500 million years and kolm--500 million years).

Academician A. A. Polkanov makes the assumption that the figure of the ageof rapakiwi-granite actually reduced considerably the large time interval between groups I and IV of the granites and simultaneously thereby increased the time interval between the formation of rapakiwi-granite and kolm.

Academician A. A. Polkanov believes that the increased age of the rapakiwi-granites, as obtained by the argon method, is due to the content therein of excess argon, the nature of which is closely connected with the origin of rapakiwi-granites. The excess argon, in the opinion of A. A. Polkanov, was contained in the synthetic magma and was occluded in a dispersed manner by the crystallizing feldspar and mica; this determined the increase in the absolute age of the rapakiwi-granite.

There were certain divergencies as regards age figures obtained for the Pre-Cambrina rocks of the Ukraine.

The commission has organized a check of the methods and work of individual age laboratories, using the material of

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of rocks and minerals of the Ukraine.

In this respect, considerable work has been accomplished by the Radium Institute imeni V. G. Khlopin, Institute of Geochemistry and Analytical Chemistry imeni V. I. Vernadskiy, VSEGEI, Ukrainian Acad. Sci. USSR in checking the figures of the absolute age for various samples of the Ukrainian crystalline massif. For this purpose, an interdepartmental commission was organized under the leadership of doctor of geological-mineralogical sciences, Yu. I. Polovinkina (VSEGEI).

The check showed satisfactory convergence of the results. For the Korosten complex, the argon method gave the following results: 1740 and 1700, 1740 and 1700 million years; for the Uman complex 1440-1500, 1400, and 1500 million years(there was also non-agreement of the results for the same sample). The work of determining the absolute age of Pre-Cambrian formations will continue, but much preparatory work is necessary in this field in connection with the more detailed study of the stratigraphy of the Pre-Cambrian deposits and volcanic stages of the Pre-Cambrian era.

The next district selected for the determination of the absolute age was the Caucasus. The first results of the investigations of the absolute age of the magmatic formations(IGEM, Acad. Sci. USSR, G. D. Afans'yev, Laboratory of the Daghestan Branch, Acad. Sci. USSR and Geological Institute of the Acad. Sci. Georgian SSR) indicate the error of refering the granites of the North Caucasian folded region to the Pre-Cambrian ancient granites.

The Caledonian magmatic cycle(Urushten complex 310-320 million years) is more ancient than all the investigated other granitoids of North Caucasus, including the porphyritic granites of the main crest, which are erroneously refered to the Pre-Cambrian era. The completed

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investigations confirm the separation of three age groups for the granite intrusions of North Caucasus: I--silurian--lower devonia; II--karbon--perm; III--miocene--pliocene.

The problem of chalk intrusions is not yet sufficiently clarified. Data on the geological position of the magmatic rocks of North Caucasus lead to the necessity of re-examining certain established views that the main role in the geological structure and magmatism of North Caucasus belongs to the Pre-Cambrian formations on the one hand and to the mesozoic, Post-Leist on the otheother hand. The first data were obtained on the determination of the absolute age of the sedimentary rocks of the Caucasus(from glauconites, M. M. Rubinshteyn).

In addition to the determinations of the age of the above indicated territories, determinations were made of the age of rocks of the ~~xxxxx~~ Primor'ye by the argon method(VSEGEI) N. I. Polevaya). The resulting data agree in most cases with the geological concepts.

I. The Mesocenozoic epoch of magmatism--determinations were made of the age for 42 specimens of intrusive and effusive rocks of South Primor'ye, which pertain to the upper chalk and paleogene magnetism. The age boundary of the upper chalk and paleogene is not distinct by ± 10 million years and the boundary between the upper chalk and the lower paleogene by 70±10 million years.

II. The Cimmerian epoch of magmatism--figures were obtained of the age; they vary within the interval of 130-160 million years(11 samples).

III. The upper Paleozoic epoch of magmatism--figures were obtained of the age of 60 specimens of "dyed" granitoids; they range from 170 to 200 million years.

IV. The Caledonian epoch of magmatism(Tuva AO)--determination was made of 25 samples of granitoids and effusive rocks of Tuva. For the most ancient Tannoul complex, absolute age values of 440-450 million years were obtained, which corresponds to the upper Cambrian era. The age for the much younger Targylak intrusion is equal to 330-340

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million years.

In agreement with these data are those which characterize the lower Devonia effusions of eastern Tuva--330-310 million years.

Determinations were started of the absolute age of the rocks of Kazakhstan, Transbaykal, Altay, and Siberia.

Determinations of the absolute age are creeping more and more into the practice of geologists. In connection with the growing number of inquiries, it is necessary to organize new age laboratories.

At the present time, the following age laboratories are already active: in Moscow--Institute of Geochemistry and Analytical Chemistry imeni V. I. Vernadskiy, ACAD. Sci. USSR; in Leningrad--Radium Institute imeni V. G.Khlopin, Acad. Sci. USSR, Laboratory of Pre-Cambrian Geology, Acad. Sci. USSR, and VSEGEI of the Ministry of Geology and Protection of Resources of the USSR; in Kiev--Geological Institute, Acad. Sci. Ukrain. SSR; in Makhach-Kala--Daghestan Branch, Acad. Sci. USSR; in Sverdlovsk--Ural Branch. Acad. Sci. USSR; in Ufa--Bashkir Branch, ACAD. Sci. USSR.

In the organizational stage are the laboratories being organized in the IGEM, Acad. Sci. USSR and in the geological institutesof the Acad. Sci. Georgian SSR, Armenian SSR, Azerbaydzhan SSR, and West-Siberian Branch, Acad. Sci. USSR, Far Eastern Construction Administration of the MTsM, and various laboratories of the geological administrations of the Ministry of Geology and Protection of Resources of the USSR.

The general scientific direction and coordination of the geochronological work is conducted by the

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commission for the determination of the absolute age of geological formations(attached to the OGGN, Acad. Sci. USSR).

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